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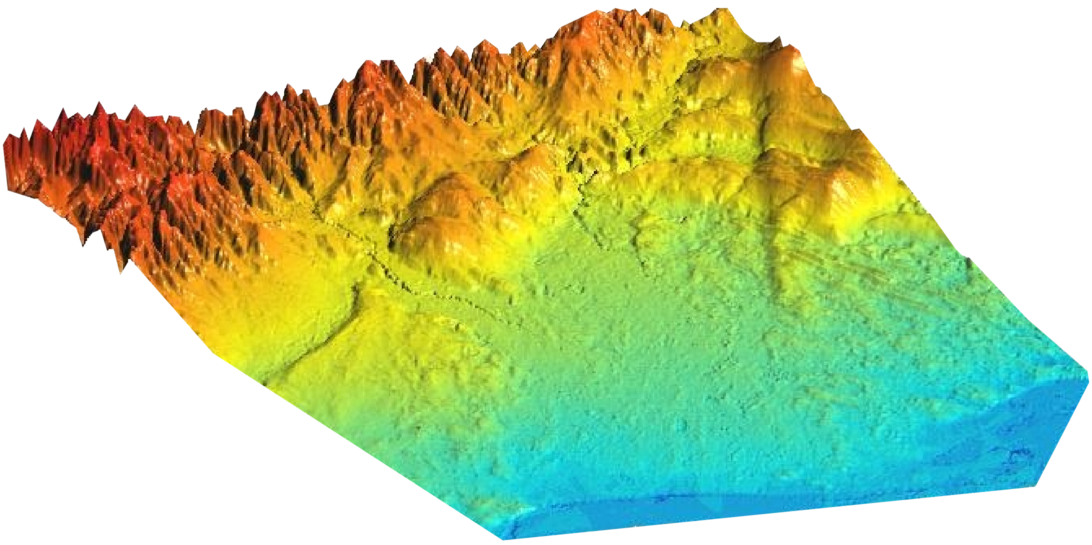
AN ENHANCED FRAMEWORK FOR NATURAL RESOURCE STUDIES IN THE ANGAS-BREMER PLAINS AREA, SOUTH AUSTRALIA



D. Gibson

CRC LEME OPEN FILE REPORT 172

September 2004

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Report prepared for the South Australia Salinity Mapping and Management Support Project.
This project is jointly funded by the South Australian and Commonwealth Governments under the National Action Plan for Salinity and Water Quality.

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ABSTRACT

This report presents an interpretation of the geology, regolith and landscape of the Angas-Bremer alluvial plain and surrounding areas. The study area is centred on the town of Strathalbyn and villages of Langhorne Creek and Milang in South Australia, and is based on interpretation of new airborne geophysical data. It links their interpretation to field investigations and targeted project drilling, along with a distillation of existing regolith, landscape, and geological data. The area was selected because of concerns regarding quantity and quality of surface and groundwater used for irrigation in the rapidly expanding prime grape-growing region around Langhorne Creek.

The new airborne geophysical data give new insight into the distribution of materials and groundwater quality of the area. The digital elevation models (DEMs) provide additional details on topography and surface processes. The airborne electromagnetics (AEM) conductivity data are interpreted to determine the distribution of salinity and sediments, and geological structure. Radiometric coverages give great detail on variations in surface materials, which in turn give clues to the underlying regolith/rock type. Field examination and project drilling helped provide additional information on the 3D distribution of materials.

The geological and geomorphological framework of the area is related to the deposition of Cenozoic sediments at the western margin of the Murray Basin, erosion of basement areas in the eastern Mt Lofty Ranges, and tectonic deformation, including tilting and faulting. Some of the fault movements may be quite recent in geological terms. The geometry of aquifers in sedimentary rocks has been affected by the faulting and tilting. In particular, faulting along the previously unrecognised Sandergrove Fault has resulted in a small groundwater basin southwest of Strathalbyn, while the main Tertiary aquifer further to the east has been offset by up to 80 m along the Bremer Fault. Downwarp associated with faulting has also resulted in areas of internal drainage which may be important for local aquifer recharge in tomes of higher rainfall.

Structure contours on the base of the Cenozoic sequence have been estimated from drill hole intersections and AEM data, and the Quaternary/Tertiary contact has been identified in many hundreds of drill holes. These surfaces can be used in new groundwater modelling of the aquifers. A fault previously thought to control the northwestern margin of the Milang groundwater basin, and to influence recharge to the basin is not evident in the new geophysical data. It is proposed that rather than having a faulted margin, the aquifer thins beneath Quaternary cover at this point. Conductivity data from the AEM suggest that groundwater recharge occurs along the Angas and Bremer Rivers across the entire alluvial plain.

The survey area is divided into ten broad areas, each with a relatively uniform distribution of soils, sediments, landscape and hydrogeology. It is postulated that each requires application of different natural resource management techniques.

1. INTRODUCTION

1.1 Background

In the Angas-Bremer Plains area, important irrigation areas (notably viticulture) and terrestrial aquatic habitats are at risk from salinity. The groundwater system is known to be complex (e.g. Telfer *et al.* 2000) and good management of the groundwater resource requires a better understanding of the hydrogeology than is currently in place. Specifically, the available management options which include improved irrigation scheduling, water re-allocation through local trading, deep drainage and pumping require a better appreciation of the soils and sub-surface geology at relevant scales. Particularly important is a better knowledge of variations associated with the shallow (<20m) unconfined aquifer systems which tend to be more saline, and the relation of these materials to a deeper, locally confined aquifer which contains water useful for irrigation. An improved understanding of this system, including associated palaeochannels (where present), could provide a basis for management strategies that combine groundwater pumping with a mix of deep and shallow groundwater-based irrigation. It would also provide a better assessment of groundwater resource and potential risks to terrestrial aquatic habitats, particularly near the Lake Alexandrina wetlands at the lower end of the Plains area.

A broadband electromagnetic system was recognised as being best suited to map the variability of water quality and materials associated with the aquifer systems present in the Angas-Bremer Plains. The need to resolve conductivity variations near surface and at depth over a large area suggested an airborne EM system as most appropriate. Also the need for information on soils, soil salinity and geological structure, given that the latter plays an important part in defining aquifer boundaries (Telfer *et al*. 2000), indicated that magnetics and gamma-ray spectrometric data would also be valuable sources of biophysical data.

1.2 Objective

The aim of this project is to better define the hydrogeological framework of the Angas Bremer Plains (Lower Murray NAP Region) and determine possible steps in the Cenozoic geological history using airborne geophysical data, allied to a detailed study of existing and new borehole information, and field observations.

1.3 Scope

This report reviews existing regolith, landscape and geological data for the area and makes a new interpretation of these based on a combined analysis of new airborne geophysical data over the area, field studies, and drilling carried out in mid 2003. Previously available information on which this report is based includes

- previously published papers
- unpublished South Australian Government reports (listed in the bibliography)
- data (including depths to geological units) on several hundred bores downloaded from the SARIG online database (https://info.pir.sa.gov.au/geoserver/sarig/frameSet.jsp) on 16th October 2002
- drillers logs of water bores (held on microfiche at the Department of Water, Land and Biodiversity Conservation - DWLBC)
- data on the Angas Bremer observation well network available on the. DWLBC website (http://www.dwlbc.sa.gov.au/).

The survey area (Figures 1, 2, 3 and 4) straddles the Kanmantoo Fold Belt and the Murray Basin geological provinces. Strongly deformed Cambrian sedimentary rocks of the Kanmantoo Fold Belt form hills in the northwest, and underlie essentially flat-lying sediments of the Cenozoic Murray Basin. In the far west, outliers of Permian sedimentary rocks are present; these may also be locally present beneath the basin rocks in the south of the area, but their presence has not been confirmed.

This report updates an earlier, more limited report by Gibson (2003a).

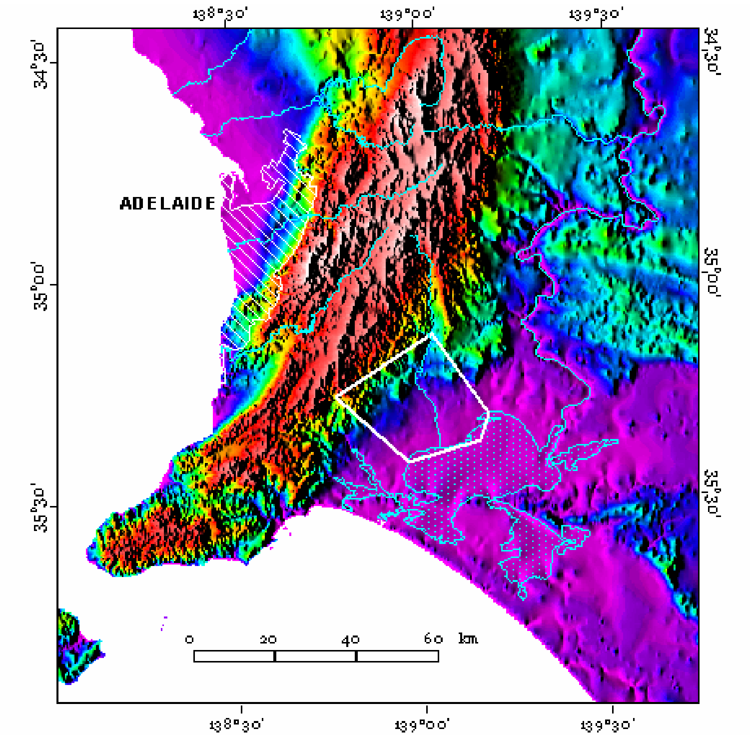


Figure 1. Nine second DEM of the region, showing location of the Angas Bremer Plains study area (outlined in white) at the eastern margin of the Mt Lofty Ranges southeast of Adelaide

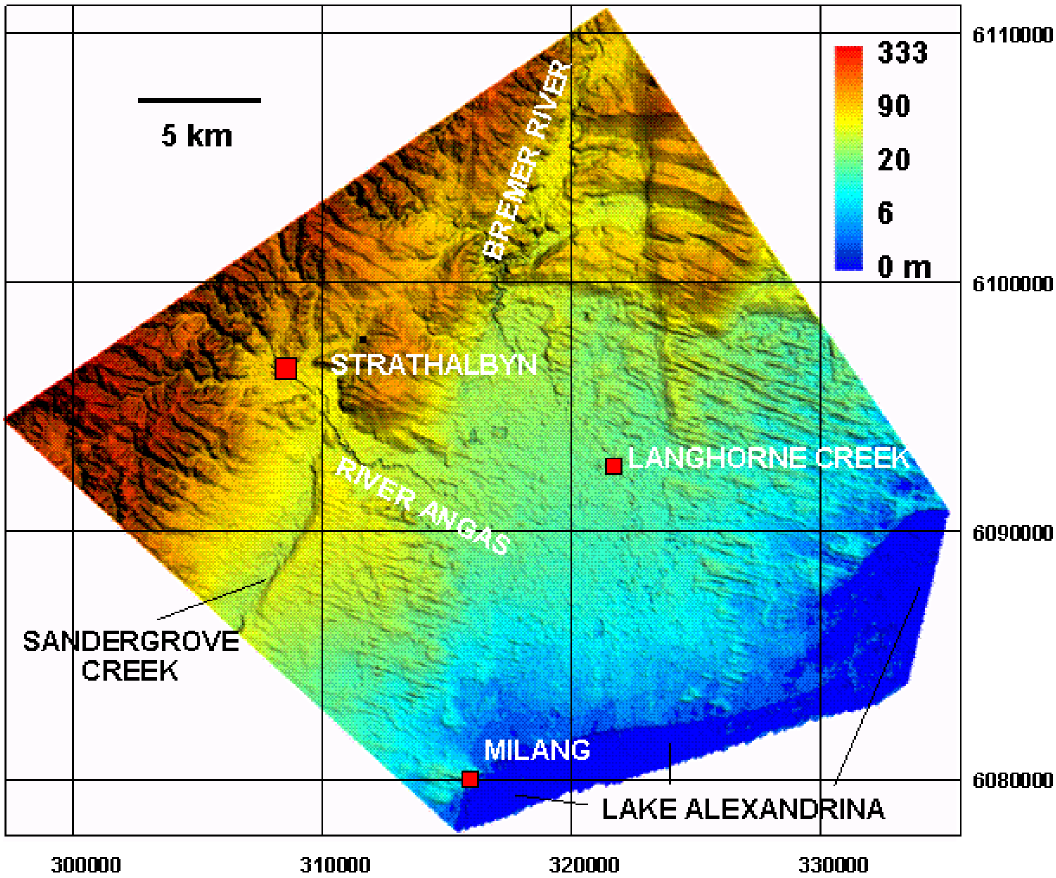


Figure 2. Radar generated DEM of the area from the 'Mag spec' geophysical survey, annotated to show locations of towns and watercourses, with sun shading from the northeast. Logarithmic colour stretch highlights variations at lower elevations.

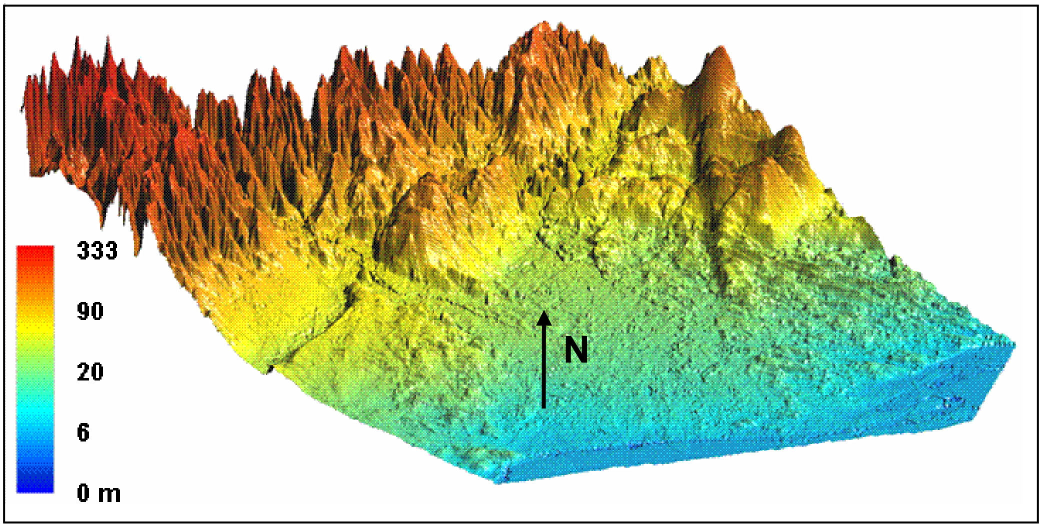


Figure 3. Oblique view of the radar DEM viewed to the north with log colour stretch and sun shading from the northeast. V/H is about 30:1 to highlight subtle variations in elevation.

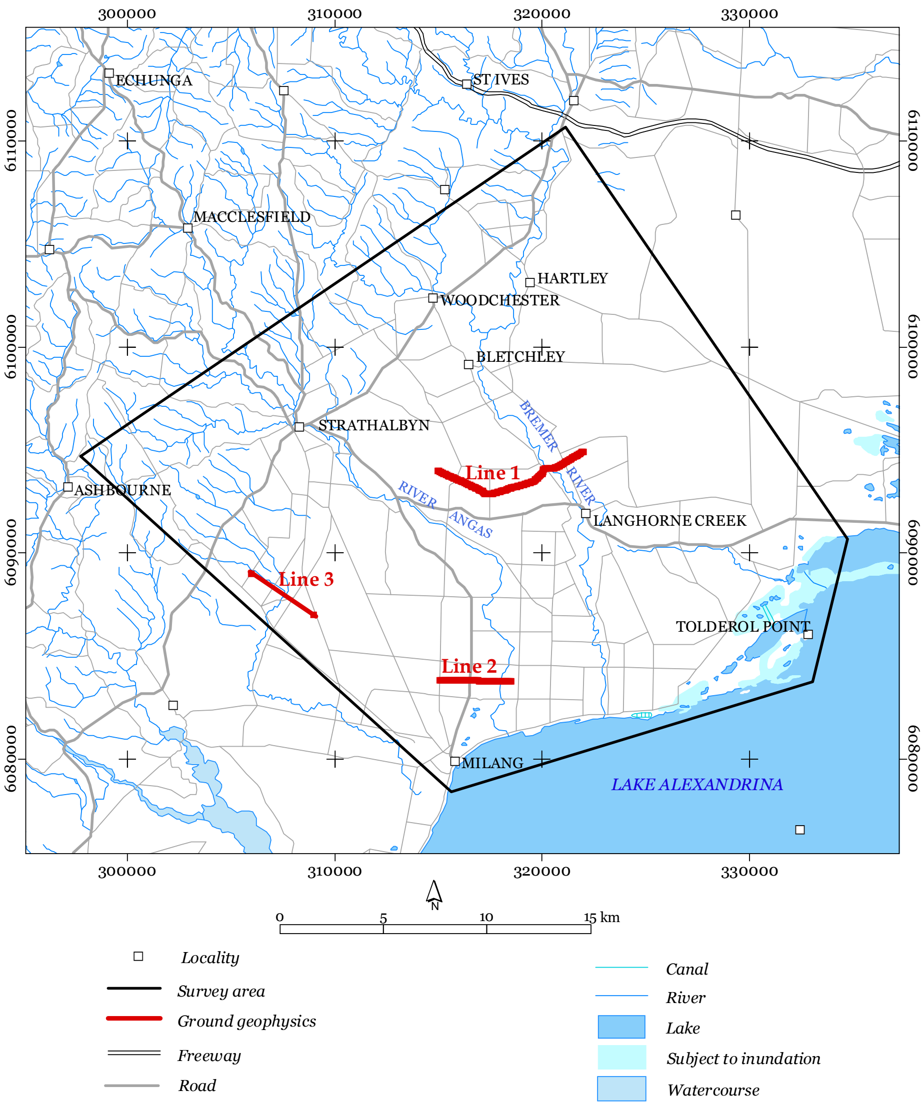


Figure 4. Study area showing principal infrastructure, drainage and location of ground EM lines.

The landforms of the area are well shown in Figures 2 and 3. These are described in more detail in Section 7 below.

In this report, the term ‘Murray Basin’ is used in a geological sense for sedimentary materials of Cenozoic age irrespective of their current elevation, attitude or water-bearing status. In the Murray Basin, there is a continuum between cemented rocks (especially limestone) and unconsolidated sediment, and thus the distinction between rock and regolith is indistinct. The term regolith was coined by Merrill (1897), who included “the entire mantle of unconsolidated material, whatever its nature or origin” over the “underlying rocks” as regolith. A further definition in the ‘Regolith Glossary’ (Eggleton 2001) includes groundwater as part of the regolith. In this report, a holistic earth materials approach is taken, as for the purposes of the current study, the modern distribution of the materials that store or transmit water and salt, the reasons for this distribution, including deposition, deformation, erosion and weathering histories, and the hydrogeological properties of the materials are important.

Salinity of water is classed as fresh (<1000 mg/l dissolved salts), brackish (1000-10 000 mg/l), saline (.10 000-100 000 mg/l) and brine (>100 000 mg/l).

All locations in this report are given as eastings and northings according to the GDA 94 datum. For field measurement of locations using GPS, the WGS 84 datum was used as a surrogate for GDA 94.

Data used in this study are stored in several locations. Data from new airborne geophysical surveys are held at Geoscience Australia, but are the property of the South Australian Government. Geological data on water and exploration bores were obtained from various South Australian Government websites, and hydrological data from water bores were obtained from the Department of Water, Lands and Biodiversity Conservation website. Data on samples from project drilling are stored in the GA ‘Deviant’ database; grainsize data for specific samples (Appendix 14) are stored in the GA Sedimentology Laboratory database. Wireline logs of these and some other holes that were available for logging in 2003 are held by the Bureau of Rural Sciences (Department of Agriculture, Fisheries and Forestry - BRS). Information on field locations is stored in the GA RTMap database.

2. GEOLOGICAL WORK CARRIED OUT IN THE STUDY AREA

2.1 Previous studies

2.1.1 Geological mapping

The Geological Survey of South Australia conducted regional mapping through the area up to the 1950s, culminating in the publication of one mile geological sheets (Milang - Horwitz & Thompson 1960; Echunga - Sprigg & Wilson 1954; Mobilong - Johns 1960; and Alexandrina - McGarry 1958) and the Barker 1:250 000 geological sheet (Thompson & Horwitz 1962). Horwitz (1960) published a lengthy paper in French on the geology for part of the area, including descriptions of some specific outcrops of Tertiary sediments. Hansen (1972) presented a report and a sketch map of the area around Strathalbyn. Maud (1972) includes a geological map that covers a small area in the northwestern part of the study area. Brown & Stephenson (1991) compiled a 1:1 000 000 map of the entire Murray Basin. In their report they included sketch maps of the subsurface distribution of various Cenozoic units which are found in the local area.

2.1.2 Geological interpretation of drill holes

All drill holes used in this study are listed in the tables in Appendix 1, which gives listings of hole locations and alternate names in order of hole ID, obswell name, and other names.

All drill holes within the study area, except the project drill holes (Appendix 12), have been numbered using a standard South Australian system of 1:100 000 sheet area number (6627 for Milang and 6727 for Mobilong) followed by a sequential number of up to 5 digits. This numbering format, referred to as hole ID, is used throughout the report, although many holes have other names as well. This numbering format may be written in several ways including with a dash (eg 6627-973) or with zeros (eg 662700973). The former is used in this report. Other names that holes may have include:

- The Angas Bremer Observation Well Network (obswell), with well names prefixed by an abbreviation of the local 'hundred' name (BRM-Bremer, FRL-Freeling, STY-Strathalbyn) followed with a sequential number. In many cases numbers below 100 refer to wells finished in Quaternary aquifers, and numbers above 100 refer to those finished in the Tertiary aquifer. These names are given in Appendix 1.
- Stratigraphic holes drilled by the SA Department of Mines, with prefix DM and sequential suffixes. Williams (1978) shows detailed graphic lithological logs of 15 of these (DM7, 8, 13, 14, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, and 27). Note that DM 14 and 20 are not included in the holes downloaded from the SA stratigraphic database.
- Company names, usually sequential, as shown in Appendices 5, 6 and 8.
- Other names that often relate to geographic areas or projects, as shown in Appendices 5 and 6.
- Nine digit identifiers such as shown in Figures 3 and 4 of Williams (1978) and Figure 5 of Bowden & Bleys (1971). This is a former state bore numbering system that uses three digits to identify the "hundred", four digits to identify the "section" and two digits to identify the bore number in the section (eg 360-3574-01, also written as 360357401). In some reports, the number is abbreviated by not using the hundred number, and deleting zeros at the start of the section number (eg numbers such as 2402 (0024-02), 338301 (3383-01) in Roberts 1972). The author does not have a complete list of these numbers, but has been able to identify numbers for several holes. These are listed in Appendix 1.

Brown & Stephenson (1986) give geological interpretations of drillers' logs of water bores over the entire Murray Basin, including 19 holes within the study area (Appendix 11). Basic stratigraphic interpretations and some detailed geological data of water, mineral exploration and geotechnical drill holes are available through the PIRSA website via the SARIG online database (direct web address https://info.pir.sa.gov.au/geoserver/sarig/frameSet.jsp). A download carried out on 16 Nov 2002 extracted stratigraphic data on more than 500 holes within the area. These are presented as Appendices 4 and 5. Data (excluding stratigraphy) on 122 mineral exploration drill holes in the study area were also downloaded, and those pertinent to the study are presented in Appendix 6. Stratigraphic data for these holes are included in Appendices 4 and 5. However, most of a series of mineral sands exploration holes drilled in the north of the area by BHP Minerals are not included. Geological interpretation of these holes is available in PIRSA Open File Envelope 8499. As the stratigraphy of these holes is important in determination of the 3D structure of the area and the report is not currently available electronically, summaries of the logs of the holes in and immediately around the study area are presented in Appendix 8.

Many water bores in the area have no interpretation of geology recorded in the SA geological database, but some of these have driller's logs that provide basic information on materials in the holes. Summaries of driller's logs used in the study are presented in Appendix 7. The driller's logs are kept on microfiche at the DWLBC in Adelaide.

Detailed geological logs of SA Government drill holes and some other water bores are kept at Government Departments in Adelaide, but these are not available over the internet. They have not been used by the author, as the detail given in the logs was not required in this study.

The basis for the interpretation of the depth of the base of Quaternary sediments in the SA geological databases is uncertain. Holes with detailed lithology appear to have good interpretations, but the majority of holes only have depths to base Quaternary and Tertiary with no lithologies given. A check of DM series holes in the database against graphic logs depicted in Williams (1978) showed that 11 of the 13 holes shown by Williams to intersect the Pliocene 'Parilla Sand equivalent' had the depth of base Quaternary in the database equivalent to the contact between sand of the 'Parilla Sand equivalent' and the underlying Miocene limestone or basement. One of the remainder (DM13, 6627-922) showed the base of Quaternary to be equivalent to the top of the 'Parilla Sand equivalent', and the other (DM 22, 6627-1184) showed base Quaternary to be at the bottom of the hole as presented by Williams, about 5 m into Miocene limestone which underlies about 5 m of 'Parilla Sand equivalent'. Thus in most of these holes, the depth of base of Quaternary in the database appears to be the depth of the top of limestone. It may be the case that the depth of base Quaternary in most of the holes in the database is the depth to Miocene limestone, and the 'Quaternary' may include thin Pliocene sediments.

The interpretation shown on the web for some holes appears to be erroneous. Drill hole 6627-1221 is recorded as passing into basement at 39.62 m, which is unexpected. The writer suggests depth should be about 100m,given the regional structure of the area. Study of the driller's log for this hole showed that it passed into 'country rock' at 39.62m. It is unclear what is meant by this term, so this hole has been ignored in any structural/stratigraphic interpretations. Observation bore FRL 143 (6727-2238) is recorded on the web as having base Quaternary at 48 m. However, Lablack (1991) shows a detailed log of the hole, along with foraminiferal determinations. This shows that Oligocene sediments extend up to at least 16 m depth, with the top of the limestone at ~19.5 m, overlain by ~3.5 m of calcareous sandy glauconitic clay.

2.1.3 Stratigraphic/palaeontological studies

Several studies of the fauna and stratigraphy of the Cenozoic sediments of the area have been published. Lindsay & Kim (1971) presented information on the micropalaeontology and stratigraphy of Langhorne Creek No 1 (DM1, 6727-1527) bore. Descriptions of cuttings samples are included. Lindsay & Williams (1977) describe Oligocene and Miocene Murray Basin sediments exposed in outliers of the Murray Basin near Hartley.

Lablack (1989, 1991) describes the stratigraphy and foraminiferal biostratigraphy of the bores BRM156 (6627-7198), STY108 (6727-2243) and FRL143 (6727-2238). The limestone aquifer in these holes is interpreted to be the Oligocene Ettrick Formation, underlain by clay and sand of the Eocene to Oligocene Buccleuch Group and overlain by thin late Pliocene sand in BRM156 (6627-7198) and unfossiliferous Quaternary sand and clay. Information is also given on drill holes DM1 (6727-1527) and DM4 (6727-1867). Lithological and foraminiferal logs of all holes except DM1 are provided.

Buonaiuto (1980) made an in depth study of the Tertiary lithostratigraphy and biostratigraphy of the area, including data on DM series drill holes available at the time and observations on outcropping Tertiary sediments.

E. Barnett (1993, 1994) studied the Holocene sediments of Lake Alexandrina.

2.1.4 Geological information in hydrogeological studies

There have been numerous hydrogeological studies of the area made by SA Government staff. As part of these studies, a series of boreholes, with names prefixed by the letters DM (Department of Mines) and followed by sequential numbers, were drilled. Logs of these holes are held by SA Government Departments; some are presented in the publications discussed below. Pseudonyms for these holes are given in Appendix 1.

Bowden & Bleys (1971) provided information on topography and geology, including an isometric topographic map, a much generalised geological map, and cross sections between drill holes drawn to scale.

Roberts (1972) included a lithological log of the recently drilled borehole DM11 (6727-1470), potentiometric contour plans, isohalines, and topographic profiles and cross-sections across the Angas and Bremer Rivers (from surveyed data). A brief landform analysis was given in an appendix to the report. According to this, the study area has been subdivided into land systems, and block diagrams drawn. However, these are not presented, and no reference is made to any publication which might give more data.

Carosone & Cobb (1975) presented contours of the elevation of the top of the limestone aquifer between Langhorne Creek and Lake Alexandrina based on drill hole data.

Williams (1977) summarised hydrogeological investigations from July 1972 to May 1974. He defined the “Milang Basin” as being the area bounded by the edge of the aquifer in the northwest, and to the east and west by the 3500 mg/l isohaline. Salinity contours, hydrographs and potentiometric contours were presented.

Waterhouse (1977a, b; 1978) presented summary reports on the area, including short sections on geology and landform.

Waterhouse et al. (1978) presented a major review of hydrogeology. They mention that prior to settlement, the Angas River discharged into swampy floodplain areas, but later a channel was dug to allow it to flow directly to Lake Alexandrina. The Bremer River has a larger flow than the Angas, and has a natural channel to the lake. Details of geology and an interpreted geological history are presented in a seven page appendix, as well as sections and isopach maps. Geological logs of wells used to prepare sections are also presented.

Williams (1978) presented details of the geological units in the area and several cross-sections. He followed up the geophysical work of McPharlin (1973) with information on depth to basement in a series of SA Government boreholes. He concluded that it was “certain that a fault marks the northern boundary of the Milang Basin where it lies below the Angas River.” He presented a structure contour plan of the depth to the Miocene Limestone surface, and a detailed interpretative geological history.

Waterhouse & Gerges (1978, 1979) presented a summary of the geology of the area, including contours of the elevation of the top of the Tertiary limestone and isopachs of Quaternary sediment, based on information from 87 wells, and a cross-section. Sheard (1979) gave a brief description of geology of the area in a report on groundwater modelling. Included in his report are logs of bores 6727-2329 and 6727-2331. S.A. Barnett (1994) summarised the hydrogeology of the region on the Adelaide-Barker 1:250 000 hydrogeological map.

Howles (1990, 1994) gave brief summaries of geology. Groundwater issues pertinent up to the mid 1990's are summarised by Howles (1995). Overdevelopment of the confined aquifer was responsible for a marked rise in groundwater salinity over the last 30 years. He states that the unconfined aquifer consists of 10-35 m of sands, silts and clays. The sands form discontinuous and inter-lensing aquifers. Groundwater salinity varies from 1000 mg/l in some areas along the rivers, up to 30 000 mg/l at some distance from the rivers. Part of this sequence forms a thin confining layer between the unconfined and confined aquifers. The confining layer is considered to be effective in the northern part of the area, but ineffective in the south.

The pre-irrigation groundwater system was interpreted to involve

- Recharge to both aquifers where the rivers cross the northern faulted margin of the basin
- Further recharge to the confined aquifer by vertical leakage from the unconfined aquifer
- Insignificant infiltration from rainfall to the unconfined aquifer
- Discharge from both aquifers which allowed continuous flushing to prevent build up of salt, via springs and lateral flow into Lake Alexandrina, and vertical leakage from the confined to unconfined aquifer in the south of the area.

Irrigation development modified the system to include

- A significant regional draw down in the potentiometric surface of the confined aquifer
- Recharge by lateral flow from Lake Alexandrina and marginal areas of the basin for both aquifers
- Major induced leakage of recirculated irrigation water from the unconfined to the confined aquifer
- Discharge dominated by extraction
- Induced leakage of saline water from the unconfined to the confined aquifer.
- Loss of flushing mechanism

To help stop these changes, artificial recharge from river flood water to the confined aquifer was carried out, reductions were made to consumption of groundwater for irrigation, and greater use was made of water from Lake Alexandrina for irrigation.

Telfer et al. (2000) presented a major review of the hydrogeology, including water levels and salinity patterns. They provided a summary of previous hydrogeological investigations and water management plans. Recommendations for the on-going management of groundwater were also made. Two geological cross-sections across the area were presented in this report.

2.1.5 Geophysical studies

McPharlin (1973) used electrical resistivity soundings and gravity measurements to determine the northwest margin of the confined aquifer. He delineated a zone of rising basement, which he considered may have been due to faulting and scarp retreat due to erosion. He considered that his proposed fault could be observed on aeromagnetic contours, and that it might influence recharge to aquifers where crossed by the Bremer River.

2.1.6 Soil/Landscape studies

A large amount of land resource information, including land system and soil landscape polygons and soil pit descriptions, are provided by DWLBC (2002). Records of individual soil auger holes are held at that Department (David Maschmedt, pers. comm. 2003). De Mooy (1959) and Maud (1972) presented soil and geomorphic information for part of the area.

2.2 Present study

The present study encompasses

- field assessment of landform, regolith and geology
- study of 1:50 000 scale panchromatic airphotos
- interpretation of new airborne and ground geophysics (AEM, airborne magnetics, radiometrics, DEM, ground electromagnetics, and wireline logs of water bores, particularly induction conductivity logs)

- drilling at 11 sites and interpretation of drill cuttings (Jones *et al*. 2003; Appendices 12, 13 and 14)
- review of existing drill hole information from SA databases
- interpretation of drillers logs
- review of previously published information

3. GEOLOGICAL/REGOLITH FRAMEWORK

The following is a summary of local geology/regolith units. Further details can be found in Horwitz (1960), Thompson & Horwitz (1962), Maud (1972), Brown & Stephenson (1991), Drexel & Preiss (1995), and many of the South Australian Department of Mines/PIRSA hydrogeological reports on the Langhorne Creek area (see section 2.1.4). A stratigraphic summary is shown in Figure 5.

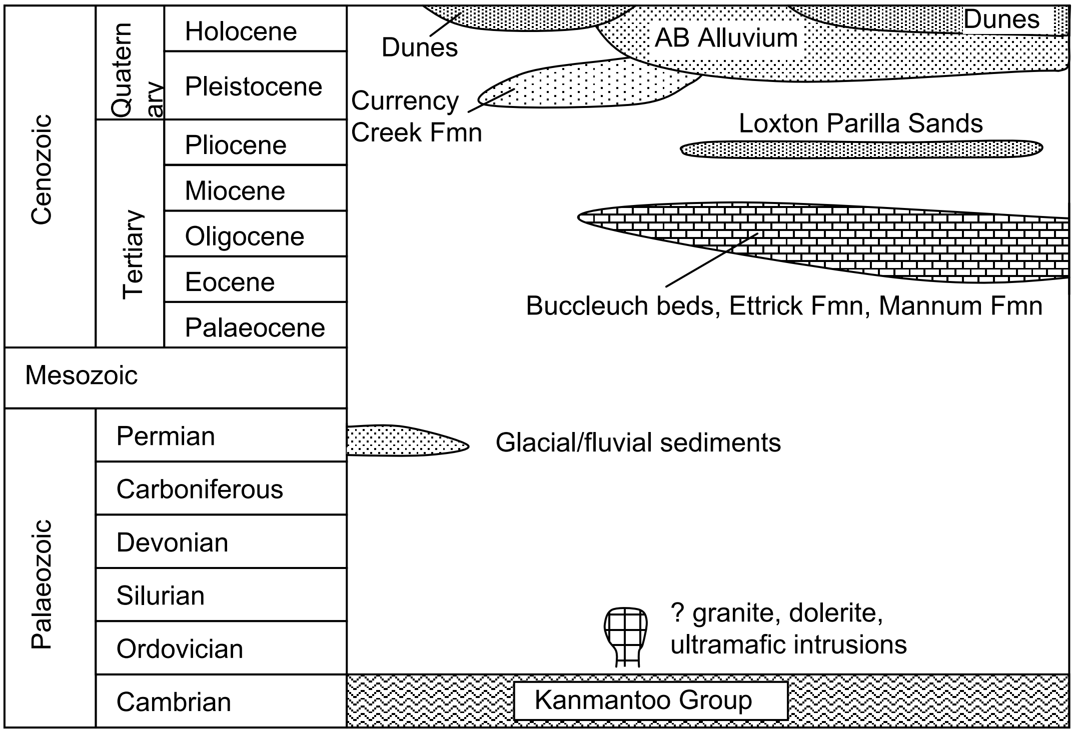


Figure 5. Diagrammatic stratigraphy of the Angas Bremer Plains area. The relationships between and ages of late Cenozoic units are not well constrained. Time axis not to scale. AB Alluvium refers to the Quaternary sediments beneath the Angas Bremer alluvial plains and the dunefields to the east.

3.1 Kanmantoo Fold Belt

Highly deformed Cambrian meta-sedimentary rocks (phyllite, schist, slate, greywacke, sandstone etc) of the Kanmantoo Fold Belt form basement to the area. These rocks have a regional north-northeast structural grain. They crop out in the hills in the west of the area, and also very locally as small inliers in low lying parts of the east of the area. These rocks probably form the basement immediately beneath the Murray Basin through most of the area.

Magnetic data gathered as part of the project indicate several large bodies of highly magnetic rock in the southern-central part of the area (Figure 6). Drill hole 81MBR 71 (6627-8148), drilled about 700 m southwest of the area close to the western margin of the largest anomaly, intersected granite beneath Tertiary sediments at the bottom of the hole between 104.0 and 104.2 m (Appendix 5). Other holes drilled to basement in the area of the large magnetic anomalies have intersected microdolerite (81MBR70) and metasedimentary rocks (several holes). It is suggested that the large anomalies represent magnetic granite that is only locally present immediately beneath the unconformity beneath the Murray Basin. Dolerite may also be locally present. Small strong magnetic anomalies in the northeast of the study area have been tested by several holes. 82LC3P1 intersected altered pyroxenite to peridotite with 1-7% magnetite (Appendix 5), but others intersected metasediments. It is suggested that many of these anomalies result from ultrabasic intrusions at depth.

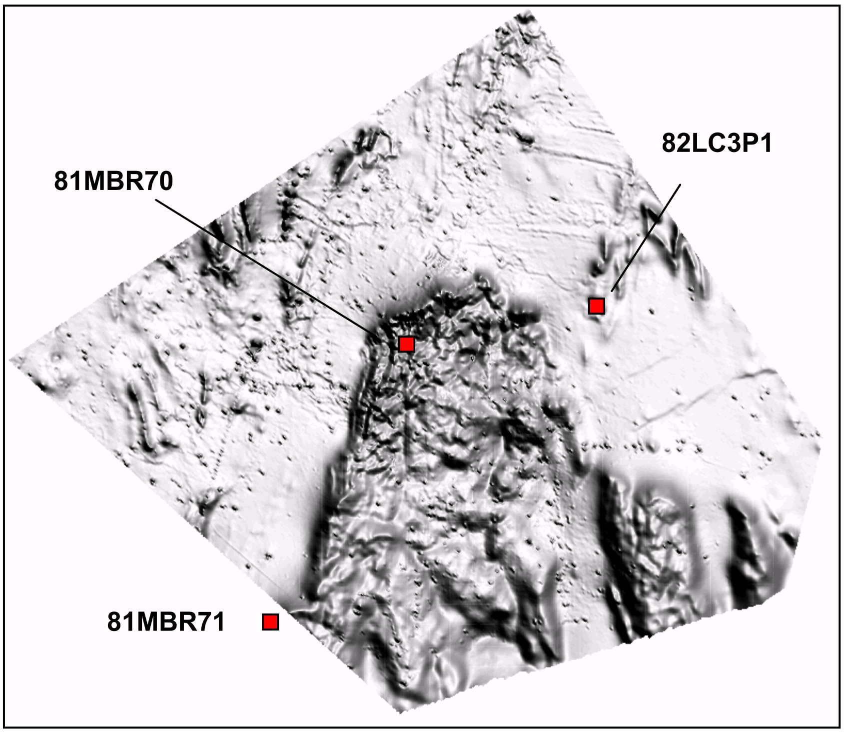


Figure 6. Greyscale Total Magnetic Intensity image with illumination from the northeast showing highly magnetic areas in the central and southern parts of the area, and other smaller strong anomalies. Drill hole 81MBR71 intersected granite, 81MBR70 micro-dolerite, and 82LC3P1 altered pyroxenite to peridotite. All other holes to basement with recorded lithology intersected metasediments, including several holes over areas with high magnetic response.

3.2 Permian sediments

Permian glacial and fluvial sediments locally overlie Cambrian rocks in the west of the study area. These sediments are essentially flat lying, although they may be locally faulted. They are preserved in lower parts of rugged terrain of the Mount Lofty Ranges in remnants of Permian palaeo valleys. Brown & Stephenson (1986) have also interpreted them to be present beneath Tertiary sediments in drill hole 6727-1527 (DM1) south of Langhorne Creek. However, Lindsay & Kim (1971) interpreted that the hole passed from Tertiary sediments into weathered Kanmantoo Group rocks. The driller's log of water bore 6627-983 (Appendix 7) records "sands at bottom with silt probably of Permian age" at the base of the hole at 66.4 m. This interpretation has not been substantiated.

3.3 Cenozoic Murray Basin sediments

These have been described by many authors in reports of the hydrogeology of the area, including Williams (1978). These published data have been supplemented by information compiled as part of this study.

3.3.1 Eocene-Miocene

Early Tertiary sediments form the basal part of the Murray Basin in the area. The late Eocene-Oligocene Buccleuch beds (carbonates, and glauconitic sands and clays) are the oldest, forming a basal layer up to 50 m thick. Lindsay & Kim (1971) described the sequence encountered in Langhorne Creek No 1 bore (DM1 - 6727-1527), and Lablack (1989, 1991) gave further descriptions. Pebbly and shelly sand between 72 and 84 m depth in project drill hole AB05 (Appendices 12, 13) are interpreted to be part of the Buccleuch beds. This unit is known only from the subsurface. Buonaiuto (1980) recognised the Kongorong and Narrawaturk Formations and an informal 'Continental Group' beneath the Buccleuch beds. He also recognised several breaks in deposition within the sequence.

The overlying Oligocene Ettrick Formation (sandy and marly limestone) and Miocene Mannum Formation (calcarenite and calcareous sands) are present over much of the area. These units form an important semi-confined aquifer, but are also present as outliers northwest of the main preserved Murray Basin near Strathalbyn, Woodchester and Hartley (eg Lindsay & Williams 1977). Lablack (1991) indicates that the Mannum Formation was not present beneath Quaternary cover in some drill holes in the area, and Williams (1978) stated that the boundary between the two formations could only be determined on palaeontological grounds. Observations made in this study indicate that large volumes of quartz grains are locally present in the carbonates, mostly as well-rounded, polished medium sized grains (0.25-0.5 mm).

Horwitz (1960) described cross-bedded Tertiary marine to estuarine sands associated with limestone in the Strathalbyn area. Recent observations have determined that estuarine to shallow marine sand and silt with minor gravel beds (strongly cross-bedded, and containing shark's teeth according to local fossickers) are present beneath Tertiary limestone in quarries and at an excavation for commercial building waste east of Strathalbyn (around 311000 6097100). Some beds within these sediments have been cemented by iron oxides.

3.3.2 Pliocene

A depositional hiatus in the middle to late Miocene separates the limestones from Pliocene sediments. This is a Murray Basin-wide hiatus, spanning about 5 million years over much of the Basin, but probably represents a longer period in the study area (Brown & Stephenson 1991). The absence of Mannum Formation beneath Quaternary units in some parts of the study area (Lablack 1991) suggests considerable local erosion during the hiatus.

In the north of the area (east of the Bremer River), Pliocene barrier dunes of Loxton-Parilla Sands (nomenclature of Brown & Stephenson 1991) are present. This area has been mapped as Quaternary sand by Thompson & Horwitz (1962), and depicted as calcrete on the geological map of Brown & Stephenson (1991). These interpretations of geology are probably technically correct, as the near surface sands have been reworked by wind, and are at least locally cemented by calcrete. However, the geological information in S.A. Barnett (1994) indicates the presence of Pliocene Loxton-Parilla Sands in this area beneath Quaternary cover, and Figure 90 of Brown & Stephenson (1991) shows the Loxton-Parilla Sands extending over much of the study area. Sand thickness in the dunes is variable; bore 6727-1415 drilled in this area is interpreted by Brown & Stephenson (1986) to have bottomed in Pliocene sand at 25 m (Appendix 11), and mineral sand exploration drill holes (BHP Minerals; Appendix 8) intersected up to 26 m of sand overlying Tertiary limestone and locally, basement. The radar DEM of the area (Figures 2, 3) indicates that modern dunes are superimposed on the barriers, with a slightly different orientation to the barrier crests. Airphoto interpretation and examination of contours on 1:100 000 topographic maps indicates the barrier dunes are probably present over an area of 250 km^2 southeast of Murray Bridge.

Brown & Stephenson (1986) interpret a discontinuous veneer of Loxton-Parilla Sands overlying Miocene limestone in bores in the low-lying areas south of the interpreted barrier dunes. These same sediments are assigned to the Norwest Bend Formation by S.A. Barnett (1994) and Parilla Sand/Norwest Bend Formation equivalents by Williams (1978), who described them as fluvial to estuarine fine quartz sand and silt, with local gravel and calcarenite. They are locally fossiliferous, and dated as late Pliocene by Lindsay & Kim (1971). Buonaiuto (1980) also reports that estuarine-marine fossils were found in this unit in DM16 (6627-864). The distribution of the sands is uncertain, but they have been interpreted to be present in many SA Government drill holes along the Angas and Bremer Rivers (e.g. Williams 1978; Lablack 1991; holes DM3 and DM4 in Appendix 5).

It is here considered probable that these sediments are a time equivalent of the sands in the barrier dunes, and thus should be considered to be part of the Loxton-Parilla Sands rather than Norwest Bend Formation which was deposited in the late Pliocene trench of the palaeo Murray River (roughly along the present course of the modern river) during a brief marine transgression that postdated deposition of the Loxton-Parilla Sands (Brown & Stephenson 1991).

It should be noted that although these sediments are of Pliocene age, they appear to have been included as part of the Quaternary sequence in brief geological interpretations in the SA drill hole database (see Appendix 4).

3.3.3 Pleistocene-Holocene

The Tertiary sediments are overlain by Quaternary sediments reaching ~40 m thick, as shown in sections in Williams (1978), S.A. Barnett (1994) and Telfer et al. (2000). The first two authors correlate the sediment with the Blanchetown Clay, which was deposited in the palaeo Lake Bungunnia further inland in the Murray Basin between about 2.4 and 0.7 Ma (Stephenson 1986). The sediments in the study area are not related to this palaeo landscape feature as they occur seaward of the interpreted dam that formed the lake, and continue in age into the Holocene (a radiocarbon date of ~3500 years for wood fragments is reported by Dury 1964). Thus use of the term Blanchetown Clay is not supported in this study. These sediments are largely mud rich, but are coarser in areas close to the margin of the Murray Basin, and contain some sand/gravel beds that may be important for local movement of groundwater.

SA Government drilling shows great variability within the Quaternary sediments that underlie the alluvial plain of the Angas and Bremer Rivers. For instance Bowden & Bleys (1971) report a marked lithological variation between two bores 200' (60 m) apart. Williams (1978) reports that the sediments are mottled, bioturbated in part, and that gravels and sands usually occur in the lower part of the sequence, and are more common upstream. The sands are more angular than the underlying Loxton-Parilla Sands, and contain maghemite. Several authors report disconformities and palaeosols within the sediments. Seven soil pits in the area exposed a variety of sedimentary materials (DWLBC 2002).

Maud (1972) defined the Cenozoic Currency Creek Formation at a type section about 7 km southeast of the study area. There is extensive outcrop of this unit along the Finniss River and its tributaries, 3 to 9 km southwest of the study area, and Maud also depicts a small area of the unit that is within the study area at the limit of his map. He also states that the formation "is well exposed in the banks of the Angas River between Strathalbyn and Langhorne Creek", although it should be noted that the Bremer River, not the Angas flows through Langhorne Creek. Thus it is most likely he equated the Quaternary sediments of the Angas-Bremer alluvial plain with the Currency Creek Formation. Maud considered the Currency Creek Formation to be probably lower Pleistocene. As deposition appears to have continued into the Holocene in the Angas Bremer alluvial plain, the use of this formation name for the alluvial deposits in the study area is not supported by this study.

Much of the low elevation area east and west of the Angas Bremer alluvial plain is characterised by longitudinal sand dunes. These are most probably late Quaternary, resulting from the mobilisation and winnowing of surface sediments in the area as well as aeolian transport of sediment from the Mt Lofty Ranges to the west. Brown & Stephenson (1991) have mapped these areas as Molineaux-Lowan Sands. Low irregular to linear dunes are also present on the Angas-Bremer alluvial plain; some of these are source-bordering dunes immediately east of the river channels.

The low-elevation dunefields east and west of the alluvial plain overlie ~20 m of clayey sediment which in turn overlies Tertiary limestone. Drill hole data indicate that the sediment beneath the dunes east of the Bremer River is micaceous and similar to that of the alluvial plains. The elevation of the land surface in this area is similar to or lower than the nearby alluvial plain indicating possible deposition by the palaeo Bremer River system. However, much of the sediment to the west is at a higher elevation than the present surface of the alluvial plain. It is suggested (section 6.1.3 below) that the area between Sandergrove Creek and the Angas River has been raised and tilted by fault movement which also stopped any movement of sediment derived from the hinterland into this area. Thus the sediment over the limestone in this area must predate the most recent phase of faulting. This sediment is most probably continuous with the Currency Creek Formation (see above) and is therefore referred to as this unit. Its relationship with the alluvium of the Angas Bremer alluvial plain is uncertain.

Many soils and upper parts of the sedimentary profile in the area are characterised by presence of regolith carbonates, either as soft aggregates, patchily developed root casts (rhizomorphic calcrete) or hardpans (DWLBC 2002; author's observations). Brown & Stephenson (1991) contend that although several calcrete horizons of various ages have been recognised in South Australia by workers such as

Firman (1963, 1966, 1972, 1973), calcrete genesis has probably continued through the late Quaternary, and is continuing today in some areas. The author has observed gravel beds containing detrital clasts of regolith carbonate in alluvial sediments that also contain precipitated carbonate. Regolith carbonate has not been observed in soils over basement rocks, and it is assumed that its presence implies presence of Cenozoic materials below.

4. SUMMARY OF GEOLOGICAL/REGOLITH/LANDFORM HISTORY

A brief description of interpreted geological history, including conclusions reached as part of this study, follows. Several hypotheses have been presented for the origin of some features in the area. Williams (1978) gives a more detailed, interpretative history, but some of his interpretations are not readily validated.

PALAEOZOIC

1 Deposition, deformation and low grade metamorphism of marine Cambrian sediments
2 Intrusion of acid and mafic igneous rocks
3 Erosion
4 Deposition of Permian glacial and fluvial sediments

LATEST PALAEOZOIC TO TERTIARY

5 Erosion. Nature of the early Tertiary palaeo landscape is uncertain, as differences in elevation of unconformity at the base of Murray Basin sediment include variations due to fault offset and tilting after sedimentation. However, the surface was likely to have some local relief, including a well-formed palaeodrainage system (Buonaiuto 1980).
6 Transgression, deposition of Eocene to Miocene Murray Basin sediments, initially marine clastic sediments, followed by calcarenite limestone. The thickness of clastic sediment is probably related to palaeo topography, with thicker sequences in palaeo lows, and limestone deposited directly on basement on palaeo highs. The shoreline was no doubt variable in location, but was probably to the west and north of the study area.
7 Uplift of Mt Lofty Range area, by tilting and faulting, in the late Miocene to Pliocene. West side down movement on Bremer and Sandergrove Faults to form west-facing scarps. Tilting of sediments in the western part of the area, with hinge zone for tilting within study area. At least partly contemporaneous with 8 below.
8 Major erosion of uplifted and tilted Murray Basin sediments during the Miocene to Pliocene during a basin-wide depositional hiatus, especially at and to the northwest of the hinge zone, and on the uplifted east sides of the Bremer and Sandergrove Faults. Possible karstification of exposed limestone. Sediment from erosion transported further downstream out of the area.
9 Probable development of the palaeo Angas and Bremer Rivers by this time: upland catchments probably similar in area to today, with river courses flowing across an eroding limestone surface roughly beneath the modern channels on the alluvial plain and then across the area now occupied by Lake Alexandrina and probably joining the palaeo Murray River before reaching an unknown shoreline location.
10 Transgression and regression during the Pliocene, deposition of quartzose barrier dunes at the shoreline during regression in the northern part of the area east of the Bremer Fault, and thin calcareous sands seaward of the dunes (Loxton-Parilla Sands). Sand, clay and gravel possibly deposited west of the Bremer Fault in the north of the area. The location of shoreline to west is not known; continued erosion of land areas to supply sediment to form Pliocene deposits.
11 Initiation of erosion of Pliocene sediments after regression. Palaeo Angas and Bremer Rivers probably re-occupy their pre-transgression courses, beneath the modern alluvial plain.

EARLY PLEISTOCENE

12 Continued erosion of basement rocks and outliers of Tertiary sediment ranges, with further uplift of Mt Lofty Ranges. Erosion of ridge along east side of Sandergrove Fault to expose basement.
13 Deposition of alluvial and possible lacustrine sediments (outwash from local streams, and possibly palaeo Angas and Bremer Rivers) at least in the west of the area (area between Sandergrove Creek and the Angas-Bremer alluvial plain) and further to the southwest (Currency Creek Formation) in the early Quaternary. Any local relief remaining on the west-facing palaeo Sandergrove Fault scarp smoothed out by sedimentation to the west of the scarp and erosion of the scarp. The courses of the palaeo Angas River and other watercourses emanating from the ranges then cross the Sandergrove Fault, depositing sediment over the Sandergrove Fault and palaeo scarp.

LATE PLEISTOCENE?

14 Further faulting and displacement of landscape, east side up along Sandergrove Fault. Previous depositional plain to the east of the Sandergrove Fault is raised, and sedimentation ceases in this area. Minor erosion only of this uplifted area. The palaeo Angas River erodes an antecedent valley through terrestrial Early Pleistocene sediment and basement rocks across the rising scarp on the east side of the fault. Possible deposition further downstream in the area of the main Angas-Bremer alluvial plain, or older Quaternary terrestrial sediments in this area eroded. Sandergrove Creek is initiated along the fault angle depression, with tributaries coming from the ranges to the west. Sedimentation continues in the area between Sandergrove Creek and the ranges. The area to west of the Bremer Fault is downwarped due to movement along the fault, reversing gradients of previously west-flowing valleys and creating areas of local drainage.

15 The palaeo Angas and Bremer Rivers deposit sediment in the area of the modern alluvial plain and in the antecedent valley eroded across the Sandergrove Fault scarp, possibly in response to fluctuations in climate and sea level. When the level of sediment reaches the elevation of the drainage divide between the palaeo Angas River and Sandergrove Creek, floodwaters from the upper Angas flow down both the Angas alluvial plain and Sandergrove Creek. At times the main channel of the palaeo Angas may have been directed into Sandergrove Creek.

16 Wind mobilisation of surface materials to form linear dunes, possibly during glacial times. Sediment on the alluvial plains winnowed and sand reworked into low dunes and mounds (possibly several phases in the late Pleistocene). Source-bordering dunes develop on the east side of the Angas and Bremer Rivers.

17 Formation of calcrete in soils on sand dunes and Cenozoic sediments (possibly ongoing throughout much of the late Pleistocene).

HOLOCENE

18 Modern Lake Alexandrina forms as sea level rises to modern levels after the last glaciation. Lake-floor and shoreline mud deposited as the rivers bring sediment to the lake.

19 Incision of the upper Angas River into sediments of the alluvial plain to form the modern deeply incised channel, probably in response to anthropogenic influences, but also possibly in response to changing climate (i.e. sediment supply, runoff, vegetation etc) or base level, or possibly a response to uplift

20 Stabilisation of many dunes by vegetation, but continued minor movement of sand. Wind deflation of sand cover exposes ?early Pleistocene sediments in localised areas between Sandergrove Creek and the Angas-Bremer alluvial plain (characterised by high radioelement response).

5. INTERPRETATION OF GEOPHYSICS

5.1 New DEMs

Two new sets of digital elevation data for the area were acquired during geophysical flying. The 'Mag spec' DEM (Figure 7) was acquired by radar altimeter during flying of the Magnetic and Radiometric survey, whereas the AEM DEM (Figure 8) was acquired using a laser prolfiler altimeter during flying of the AEM survey.

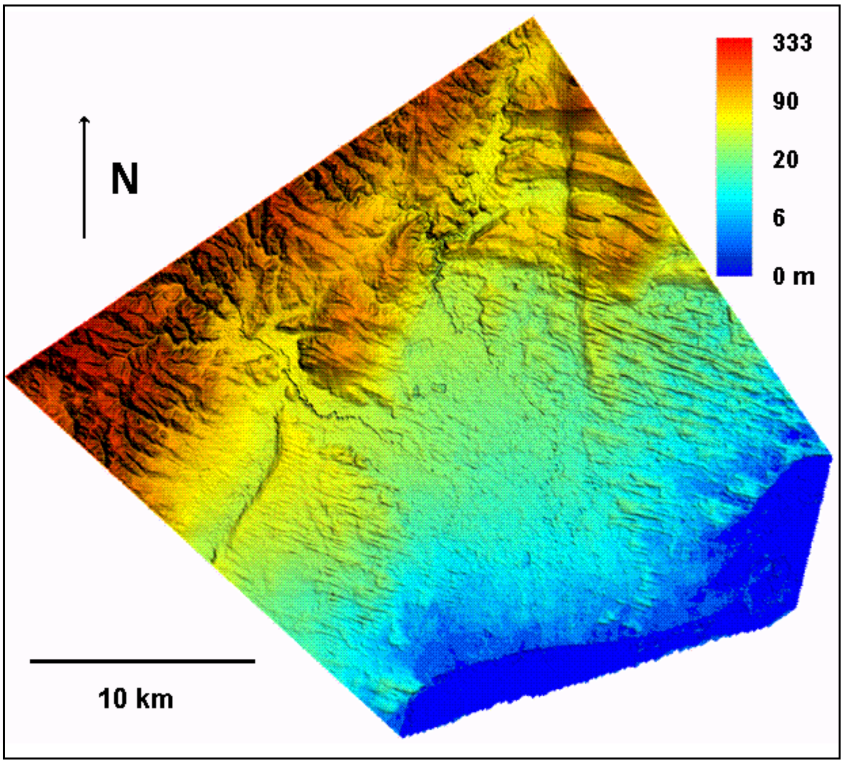


Figure 7. Radar DEM from the 'Mag spec' survey (100 m line spacing) with illumination from NE. A logarithmic colour lookup table has been used to accentuate variations at low elevations

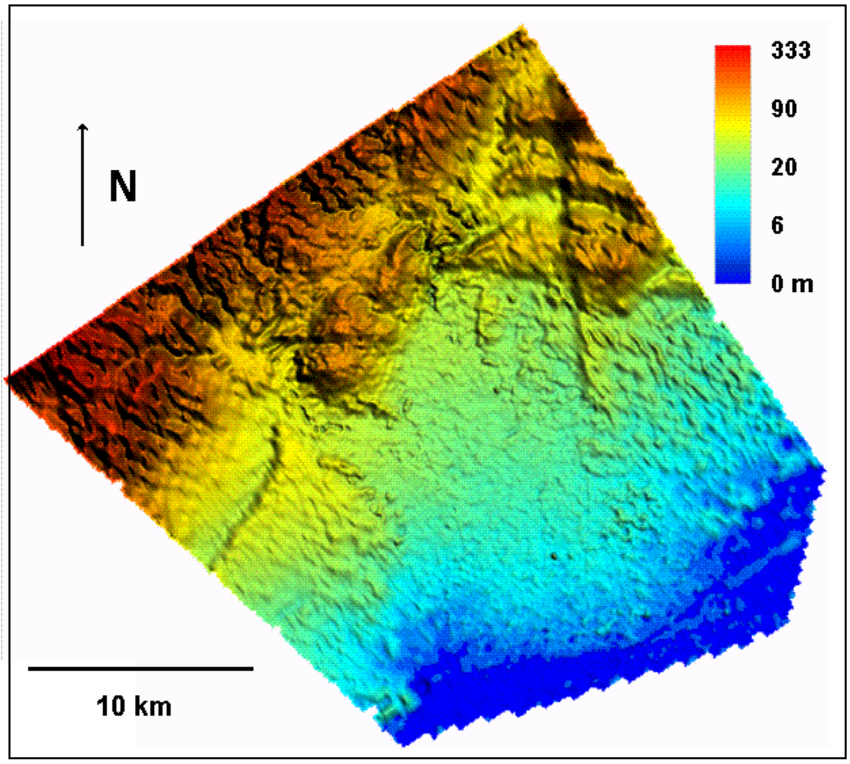


Figure 8. Laser DEM from the AEM survey (150 and 300 m line spacing as shown in Figure 10) with illumination from NE. Note poor horizontal resolution compared with the radar DEM in Figure 7.

Theoretically the laser should give more accurate results, but as the flight lines for the AEM survey were more widely spaced (150 and 300 m; see Section 5.2 and Figure 10 below) than the radar (100 m), the resulting DEM after gridding does not appear as detailed. Both DEMs gives great detail compared with the previously available 9 second DEM (Figure 1).

5.1.1 Limitations to the new DEMs

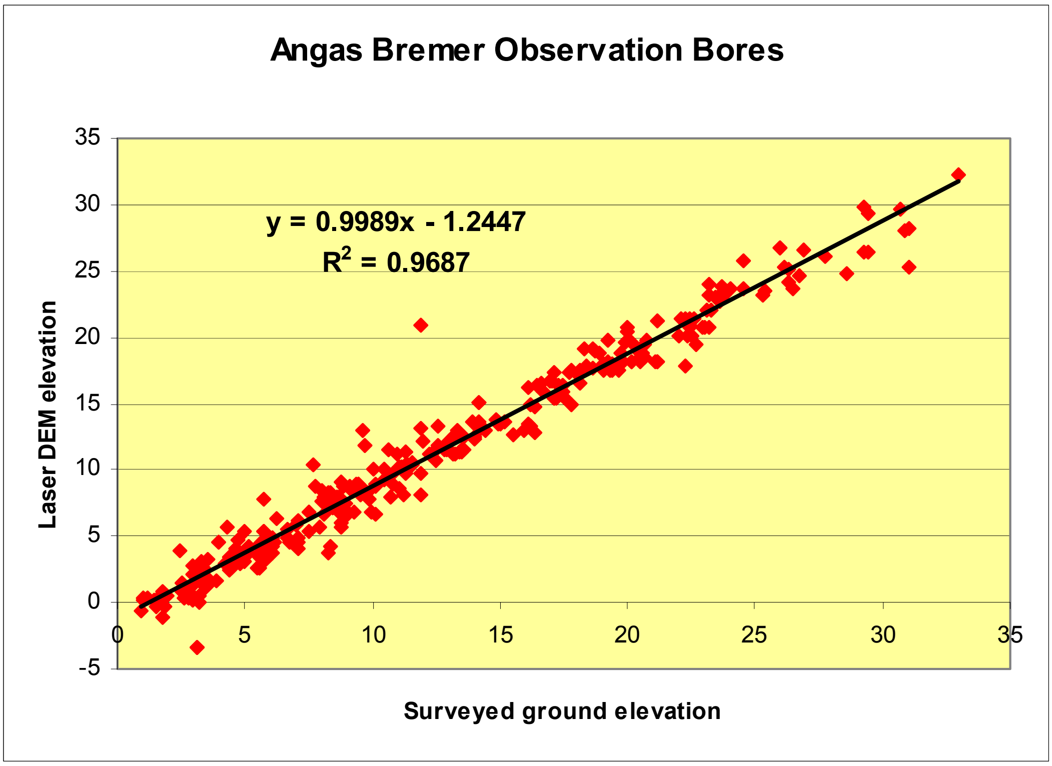
There are some shortcomings with the new DEMs, particularly in the depiction of incised channels associated with the Angas and Bremer Rivers. Locally these channels appear discontinuous or absent. There are also some 'paddock' effects (Brodie & Lane, 2003) in the radar DEM. Inaccuracies can be attributed to many causes, including:

1. The DEMs are generated by gridding elevation data gathered vertically beneath flight lines. Thus small features not directly crossed by a flight line will not appear on the DEMs.
2. Linear features at low angles to flight lines may not be adequately shown, due to errors generated during gridding. This is the case for some sections of the entrenched channels of the Angas and Bremer Rivers, which locally appear as a series of small closed depressions normal to the flight lines rather than continuous features. West-northwest oriented linear sand dunes are not imaged well on the AEM DEM, due to the larger line spacing. Instead, gridding has tried to join features more normal to the flight lines (parallel to the northwest boundary of the area) to give the appearance of more north-northwest oriented features. Many sand dunes are shown on the radar DEM as having small elevation variations along their crests normal to the flight lines and arranged in an *en echelon* fashion. Additionally, some roads appear as a series of small *en echelon* anomalies.
3. The elevation information is not collected continuously along the line, but at 0.1 second time intervals, corresponding to about 7 m distances along the line. Thus steep landforms (e.g. the incised channels of the Angas and Bremer Rivers) may not be properly depicted.
4. Radar waves can be scattered by moisture or ground roughness of certain wavelengths, particularly in ploughed paddocks, to give a slightly lower estimate of elevation than is actually present. Thus some paddocks appear as slight depressions on the radar DEM, eg around 316100 6093600. At this locality a local depression in the Angas Bremer alluvial plain of up to 4 m is suggested by the DEM, but this is not evident on the ground or in airphotos. The AEM DEM does not show this depression.
5. Radar and laser can be reflected by vegetation. Thus some roads with dense roadside vegetation appear as linear ridges.
6. The laser DEM was obtained using a laser profiler system. Any variation of the laser beam from vertical (due to pitch of the aircraft, incorrect mounting etc) will result in a low estimate of elevation.

Thus there is expected to be a certain amount of inaccuracy in the DEMs. However, detailed study of topographic profiles suggest that local features with less than 1 m relief (such as natural levees along watercourses and low sand dunes) are resolved with the radar DEM.

As a test of the vertical accuracy of the derived DEMs, the locations of the Angas Bremer Plains network of observation wells (from the DWLBC website, February 2004) were intersected with the DEMs, and the resulting elevations compared with the surveyed ground elevations for the wells (also from the DWLBC website, February 2004). The data are shown in Appendix 2 and summarised in Figure 9. Both DEMs gave good estimates of elevations ($r^2 = 0.97$, and slope of the relationship very close to 1) compared with the surveyed data. There are several possible reasons for differences between the surveyed elevations and those estimated from the DEMs, including inaccuracies in the DEMs due to effects listed above, but we note that even though elevations of the bores may have been accurately surveyed, horizontal locations of the holes may not be accurate, leading to intersection with the DEMs at incorrect locations. For example, obswell FRL 65 (6727-1570) was shown in the SA databases up till late 2003 to have location 324762 6082345. This was amended to 324326 6082288 on the basis of a new GPS reading taken by BRS staff during wireline logging of the hole (John Spring, BRS, pers comm. 2003), the new location being about 450 m distant from the old. On average, the laser DEM appears to be underestimating the elevation by about 1.25 m (regression line intercept on the Y axis in Figure 9A).

A



B

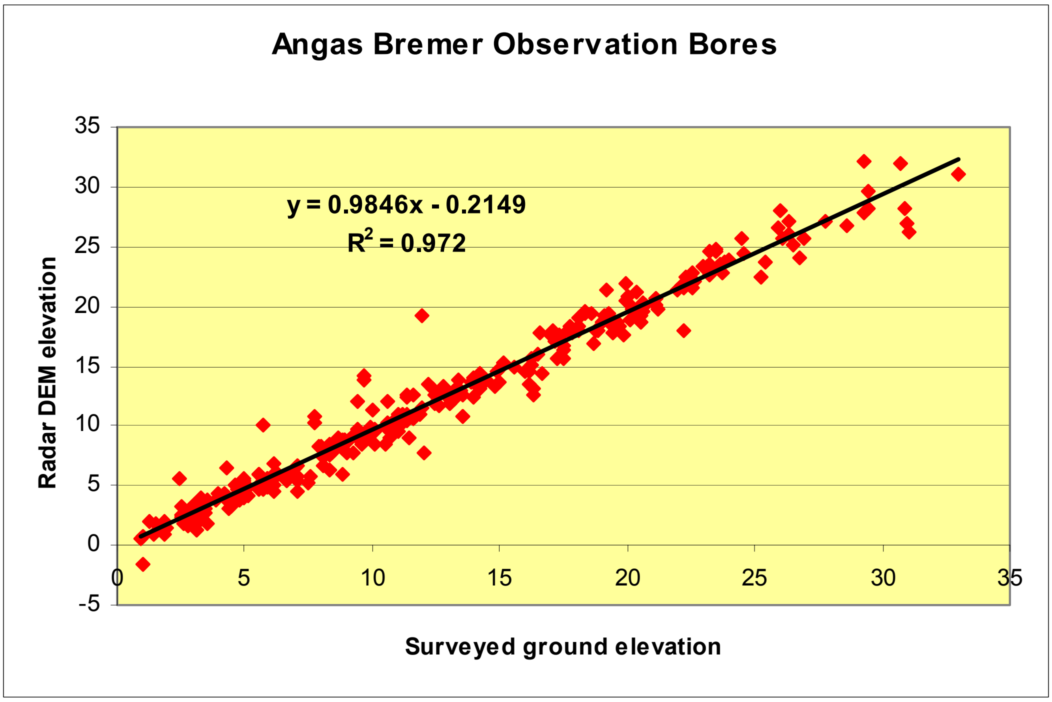


Figure 9. Elevations of the Angas Bremer Observation Well Network (309 wells) estimated by intersecting well locations with the DEMs, plotted against surveyed ground elevations. A. Laser DEM. B. Radar DEM.

The vertical accuracy of the DEMs can also be expressed by the magnitude of the errors (i.e. the difference between the surveyed and the DEM-derived elevations). Percentiles for the errors are given in Table 1. The data suggest that the radar DEM and laser DEM (after applying a correction of +1.25 m) have similar accuracy. The scatter of data suggest that although elevations can be fairly accurately estimated from the DEMs, there is still a 10% chance that the estimated elevations are in error by more than ~2 m, and 33% chance that the estimated elevations are more than ~1 m in error. It should be noted that elevations used in this study are below 35 m, and thus there is no indication of the vertical accuracy of the DEM at higher elevations.

	50 percentile	67 percentile	90 percentile	95 percentile
Radar DEM	0.66 m	1.05 m	1.99 m	2.85 m
Laser DEM	1.33 m	1.77 m	2.88 m	3.14 m
Laser DEM + 1.25 m	0.71 m	1.01 m	1.90 m	2.51 m

Table 1. Absolute difference (metres) between the surveyed ground elevations and elevation estimated for boreholes in the Angas Bremer Obswell network, expressed as percentiles. Thus 50% of the estimations from the radar DEM are within 0.66 m of the surveyed elevation, 90% are within 1.99 m etc.

5.2 AEM

5.2.1 Introduction

The Airborne electromagnetic technique measures induced conductivity within the ground. There are two main types of survey, time and frequency domain. The latter uses alternating currents of various frequencies. The former, used in this area, uses a pulse of current in an antenna array on an aeroplane, and measures induced current in the earth at various times after the pulse, via a receiver in a towed sonde. Conductivity (CDI – conductivity depth images were used in this study) of the earth is calculated from the measured secondary currents at fixed points along the flight lines, and data from these points is gridded to form a 3D modelled conductivity space. The conductivity data are usually plotted in two dimensions as sections along flight lines, and depth slices. In the current study, CDIs were calculated over 5 m depth intervals down to 200 m below the surface. In addition, to allow easier interpretation in areas of topographic relief, elevation slices over 5 m intervals were calculated for elevations between –150m and +320 m. The AEM data supplied by the contractors Fugro Airborne Surveys were reprocessed by A. Fitzpatrick of Geoscience Australia, using the latest available version of EM Flow (version 5.30, available through AMIRA Project P407B) (Fitzpatrick 2003). Adjustments were also made to the antenna configuration to maximise correlation with known conductivity structure from wireline logging (induced conductivity using a Geonics EM 39 probe) of drill holes carried out by BRS in 2003.

The Angas Bremer Plains survey was flown with line spacings of 300m, with additional lines flown in the central part of the area to give spacings of 150 m (Figure 10). This was to allow more detailed imaging of small potential targets beneath the Angas-Bremer alluvial plain.

Ground conductivity depends on many factors, the most important being the water content of the earth materials, salinity of that water, mineralogy, and the pathways available for electric current to flow. Previous work in the Gilmore study area in central NSW has shown that in wet porous materials salt load (i.e. the product of moisture content and salinity of the water) is proportional to conductivity (Cresswell *et al*. 2003). Thus conductivity levels cannot be directly related to salinity of groundwater, as the porosity and saturation of the medium has to be taken into account. For example, fractured bedrock with saline water is generally (but not always) imaged as a resistor, as the bulk moisture content may be only several percent. Similarly, saturated clay and sand with similar water salinities will have higher and lower conductivities, as clay has higher porosity and thus moisture content than sand (although the clay may have a very low hydraulic conductivity compared with the sand).

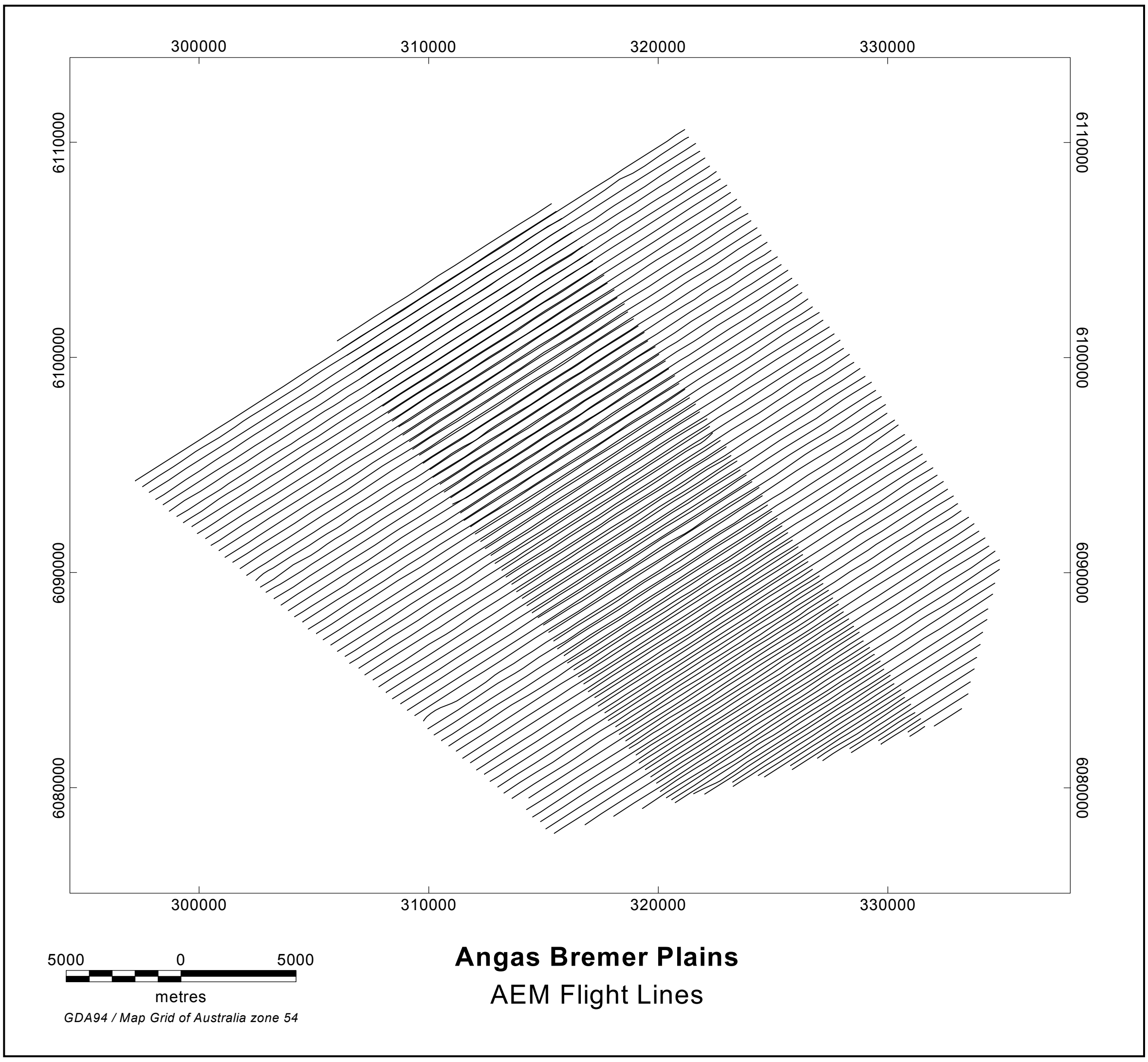


Figure 10. AEM flight lines for the Angas Bremer Plains study area.

The modelled conductivity profiles are a simplification of the actual ground profile, as there are limits to the thickness and areal extent of conductors and resistors that can be imaged and sudden changes in conductivity with depth are smoothed out. A rapid drop in conductivity with depth (for example porous sediment with saline water overlying basement rocks with low bulk moisture content) will in many cases be modelled as a gradual decrease (D. Hunter, CSIRO, pers comm. 2001).

Thumbnails of representative conductivity depth intervals for the study area are shown in Figure 11. Conductivity is expressed as milli-Siemens per metre (mS/m).

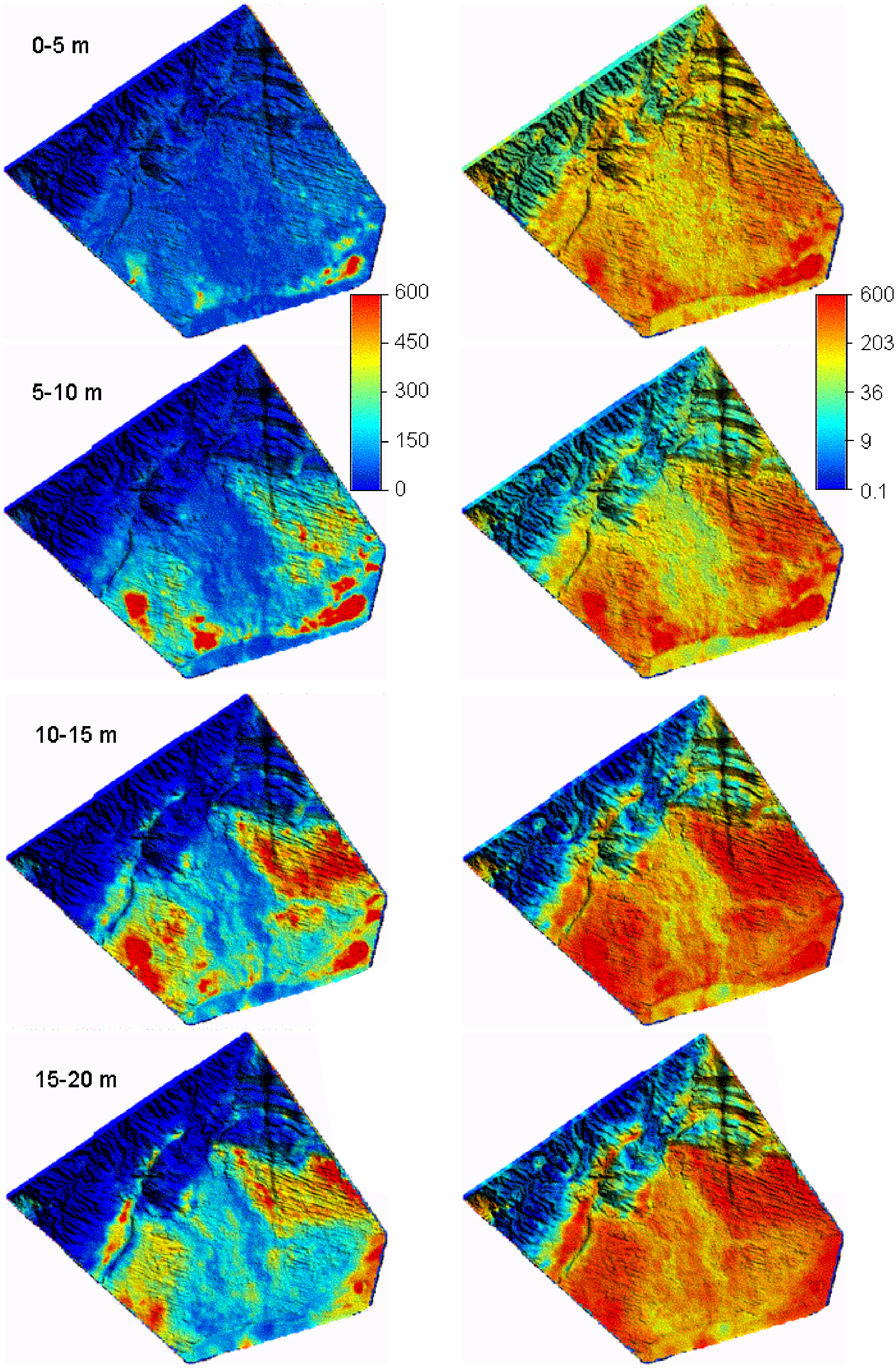


Figure 11. Representative CDI depth slices with linear (left) and logarithmic (right) colour stretches 0-600 mS/m, over greyscale DEM illuminated from the northeast. Continued over page.

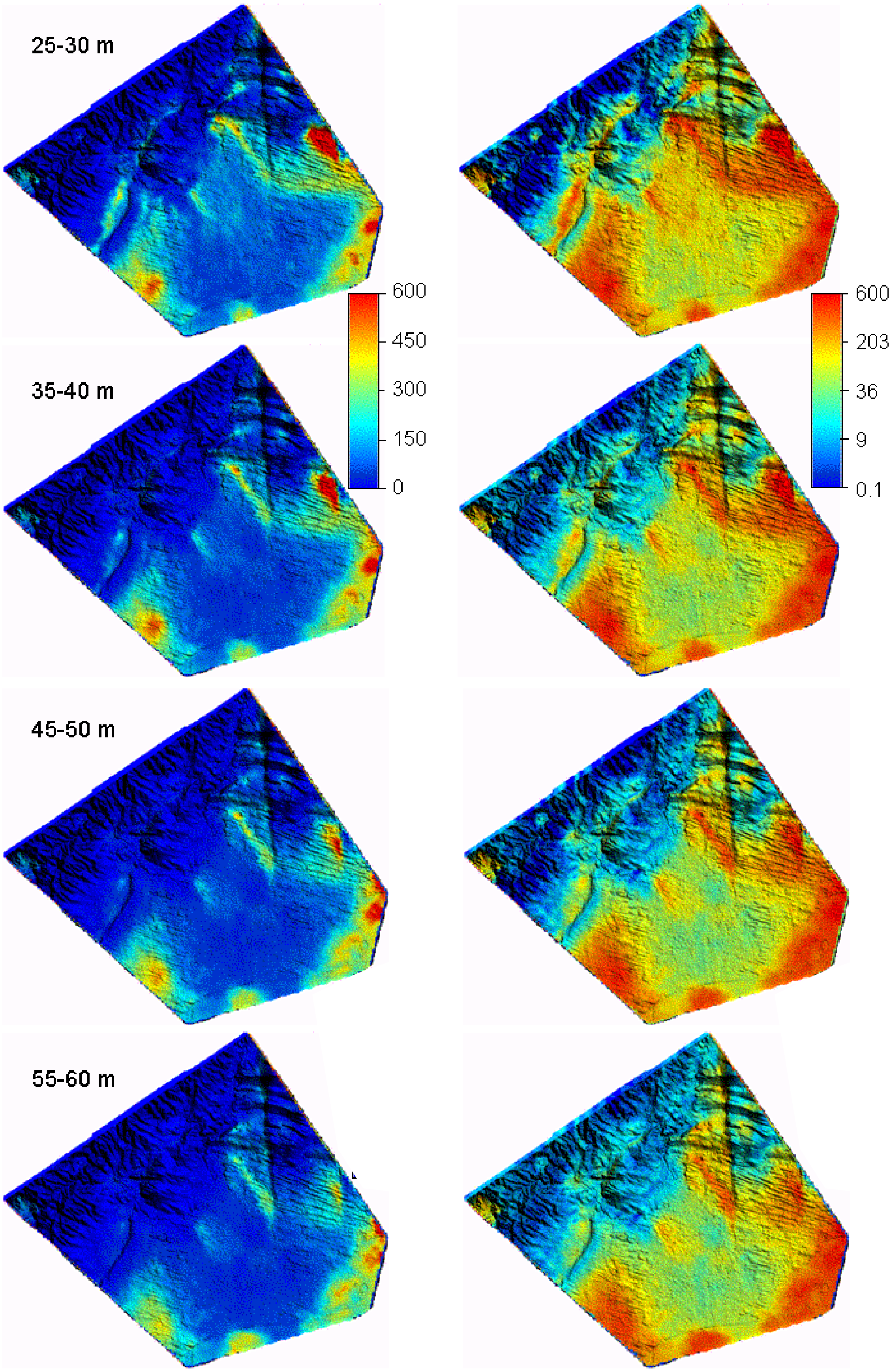


Figure 11.Continued

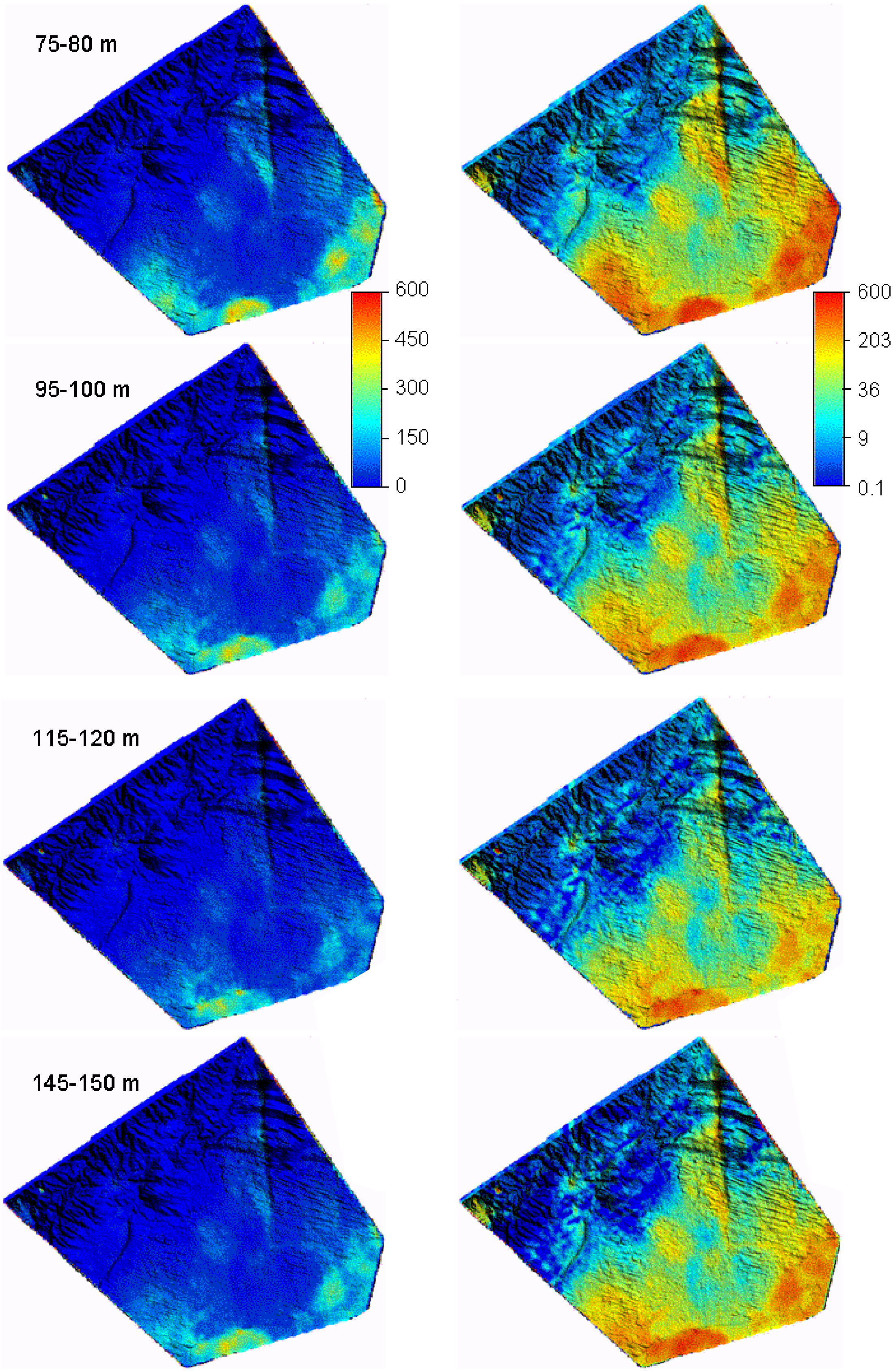


Figure 11.Continued

5.2.2 Groundwater salinity

Within saturated porous media (eg most of the Cenozoic sedimentary sequence), conductivity is influenced by salinity of groundwater and porosity (i.e. fluid content) of the earth materials. As a test of how well the AEM conductivity predicts salinity in this area, the salinity of water from bores in the Angas Bremer Observation Network was compared with AEM data (Appendix 3, Figure 12). Only those bores identified as producing water from the Tertiary aquifer were used, and salinity values from 1999 to end 2003 (there is a hiatus in data from 1996 to 1999) were averaged to give an estimate of salinity of the bores in recent times. These figures were plotted against the gridded CDI conductivity for the bore location as recorded in the database, at the depth of the top of the screened interval in the holes (from the website).

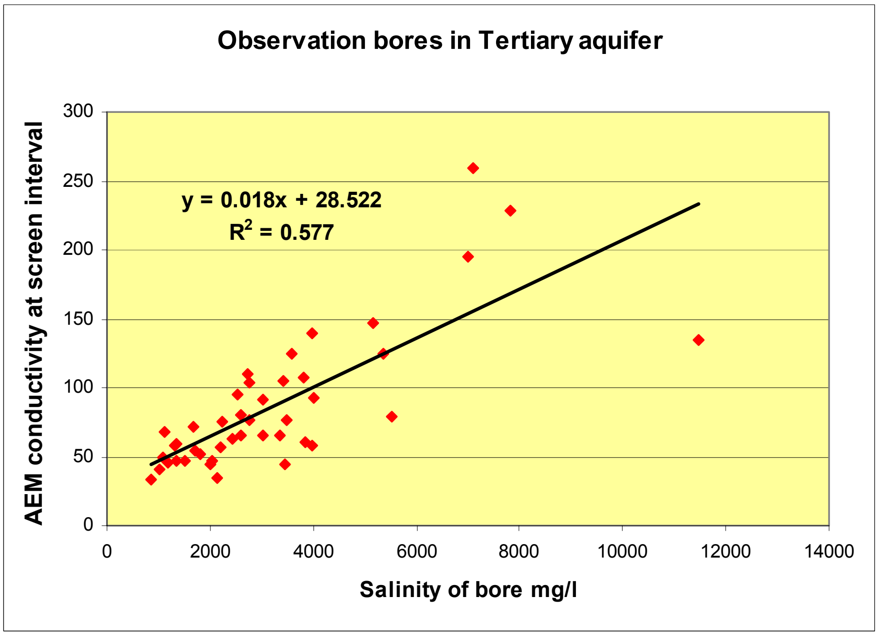


Figure 12. Average salinity of Angas Bremer Observation Wells for the period 1999-2003 compared with AEM conductivity (mS/m) at the depth of the intake screen.

Figure 12 shows there is a general increase in conductivity with salinity, but the correlation is moderate (r^2=0.58). It is possible that porosity variations or inadequate depiction of true conductivity by the inversion of the AEM data are some of causes of the spread of data.

The deeper CDIs clearly show areas of high conductivity in the Tertiary aquifer away from the Angas Bremer alluvial plain, corresponding to high salinity groundwater (Figure 11). However, the Tertiary aquifer in the area between the Bremer Fault (see section 6.1.1) and the Bremer River, north of the alluvial plain and low dunefields (north of 6100000 m north), has variable conductivity (Figure 13). Information from the SA water database and local landowners suggests that water with salinities as low as 2000 mg/l is present locally in this area. It is possible that areas with low CDI conductivities such as depicted on Figure 13 contain better quality groundwater in the Tertiary aquifer in this area. A water sampling program and new drilling targeting areas of lowest conductivity would help to establish whether the AEM data can be used to predict better quality groundwater in this specific area.

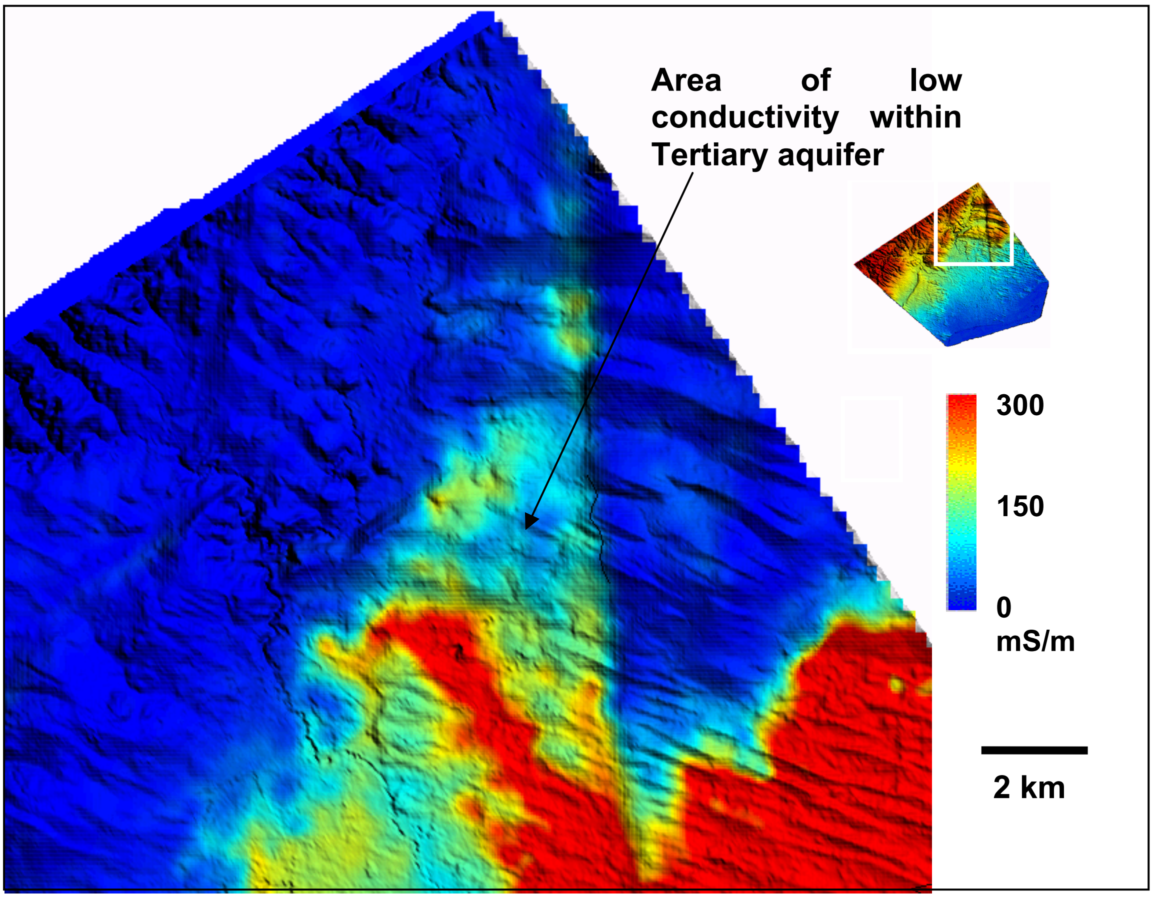


Figure 13. CDI elevation slice for plus 5 to 0 metres elevation, colour stretch 0-300 mS/m linear (over greyscale DEM with illumination from the northeast) showing an area of low conductivity in the Tertiary aquifer in an area of hills north of the alluvial plain.

There is a small elongate northwest-oriented area of high conductivity in the northwestern part of the alluvial plain, between the Angas and Bremer Rivers (Figure 14, between about 316300 6092200, and 317600 6090100). There are no observation wells within this area, but several bores in the SA water database are listed as having salinities of up to 7 000 mg/l (bore 6627-914, 316725 E 6091308 N: this bore penetrated 15.4 m into the Tertiary aquifer, and it is assumed that the tested sample is from this aquifer). Bores around the area of high conductivity have lower salinities. The northwestern end of the anomaly dips to the southeast, and appears to correspond with the sediment/basement contact in this area. There are several possible causes for the high salinities recorded. They could result from introduction of saline water into the aquifer via a conduit from basement to the northwest, thus being a plume. Alternatively it could be due to lack of recharge. Close study of the radar DEM indicates that the anomaly lies mostly beneath an area of source bordering dunes on the left bank of the Angas River (see Section 7.9.1). The slightly raised elevation of these dunes compared with the alluvial plain immediately around the Angas River, and low-lying areas to the north, means that recharge from floodwater cannot occur in this area.

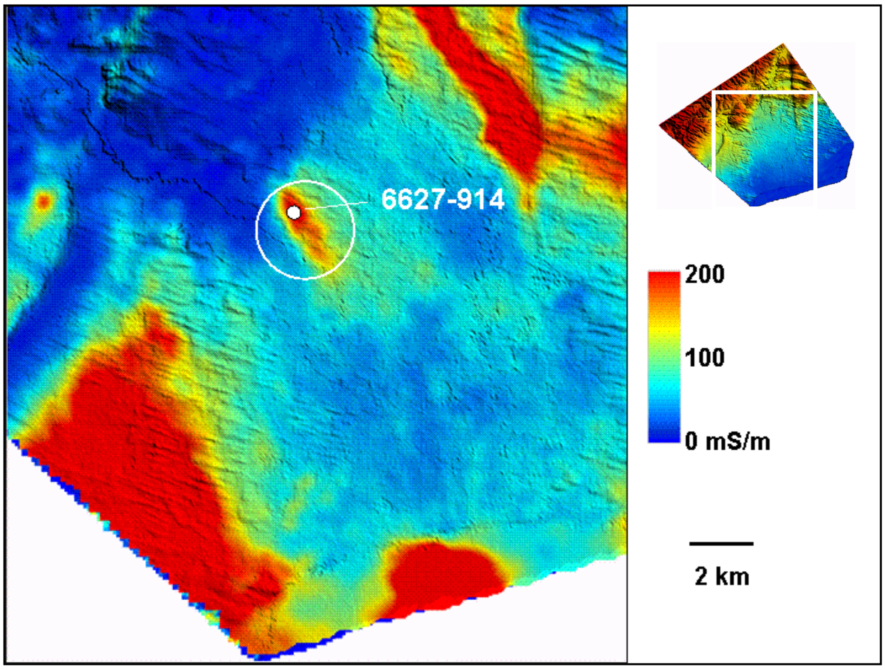


Figure 14. Minus 15 to minus 20 m elevation CDI slice with linear stretch 0-200 mS/m (over greyscale DEM with illumination from the northeast) showing an elongate conductivity anomaly between the Angas and Bremer Rivers within the Tertiary aquifer (circled). Bore 6627-914 (white square) has water of ~7000 mg/l (SA water database), most probably taken from the Tertiary aquifer.

5.2.3 Depth to basement

Conductivity data can be used to help determine geometry of earth materials, as different materials may have varying water contents, salinities, or matrix conductivities, all of which may affect the overall conductivity. In particular, the location of the contact between water-bearing porous sediment and low moisture content basement should be able to be estimated, even where there is not a contrast of salinity between the two lithologies. Ideally, a particular conductivity value might be able to be used to model the sediment/basement contact. However, this was not the case in the study area, as the modelled CDI conductivity values at the locations and depths of the basement/sediment contact (known from boreholes) vary widely (Figure 15, data in Appendix 9). This is probably due to varying water salinities within the sediment, varying basement conductivities, a varying thickness of the conductive sedimentary layer, varying degrees of weathering of the basement immediately below the contact, and variability in the extent that the CDIs accurately model the true ground conductivity.

Results suggested that there was no rigorous way to calculate the location of the base of the sediment from the CDI conductivity values. Further studies might show that features such as inflexion points on conductivity profiles relate to the contact, but this is outside the scope of the present study. However, locations of structure contours of the base of the sediment have been estimated based on the intersections in drill holes (Appendix 9) coupled with an interpretation of conductivity elevation slices (slices showing conductivity at a certain elevation with respect to the Australian Height Datum, AHD, rather than at a depth below ground surface) and broad knowledge of the structure of the area. The area around each drill hole was worked on separately. The conductivity elevation slice that corresponds to the sediment/basement contact for each drill hole (eg contact at minus 52 m AHD, use minus 50 to minus 55 m elevation slice) was displayed on screen. The data for that slice were then used to draw a local structure contour (in this case minus 52 m), passing through the location of the drill hole. After generation of the local structure contours around each drill hole, contours at 20 m intervals were drawn across the area, using the local contours as guides. The contours were saved as spreadsheets of eastings and northings of points along the contour line and the AEM conductivity at each point The structure contours have varying expected accuracy, depending on the density of drill hole information and the local conductivity structure. The location of basement could be better estimated where there the sediment was highly conductive, i.e. with saline water. As a consequence, the locations of structure contours are probably least accurate beneath the Angas Bremer alluvial plains where groundwater is freshest. The structure contours and drill hole control points (Appendix 9) are shown in Section 6 below.

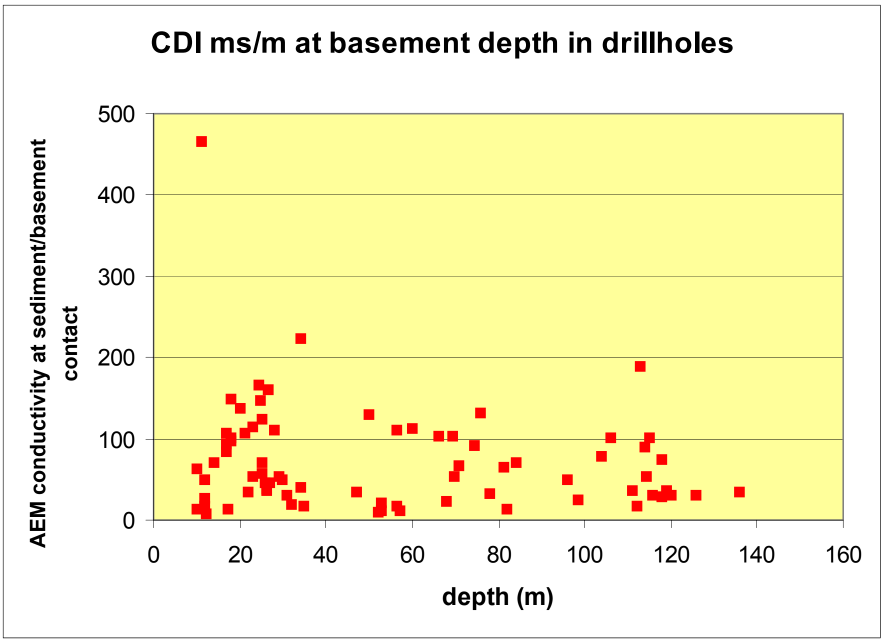


Figure 15. CDI conductivity at the basement-sediment contact in drill holes, plotted against depth of the contact. The scatter shows there is no single conductivity value or conductivity-depth relationship that could be used to predict depth to basement from the conductivity data. Data are from Appendix 9.

5.2.4 Faults

The AEM data show sharp discontinuities at various levels that are interpreted as faults where sediment and basement are juxtaposed, that is faults with post-Miocene movement (Section 6.1 below). The locations of these faults have influenced the geometry of the derived structure contours. A near vertical fault will show virtually no migration of the discontinuity with depth, whereas a dipping unconformity contact that is characterised by a conductivity contrast will migrate laterally with depth. Therefore examination of a range of depth or elevation slices or a CDI section will help to determine whether an abrupt change in conductivity on a slice can be attributed to a fault or shallow dipping contact.

5.2.5 Shallow conductivity anomalies

The 0-5 m CDI depth slice shows three main areas of high conductivity (Figure 16). The most western of these corresponds with an area of clay soils with gilgai mapped by DWLBC (2002) in the dunefield between Sandergrove Creek and Milang. This area is interpreted as a deflation window in the aeolian sand cover in this area, and has high radioelement response which contrasts with the low response from the surrounding dunefields (see Figures 21, 56). Soil site CH010 in this area (at 310500 6085150) (DWLBC 2002) has heavy alkaline clay soil with imperfect to poor drainage, which is waterlogged in wet years. It is described as having “moderate” subsoil salt levels. Thus the conductivity is interpreted to result from the salt content and high moisture in clay soil.

A second area northeast of Milang corresponds to an area of very low elevation (Figure 17). Project drill hole AB09 drilled in this area encountered conductivities (measured with a Geonics EM39 induction conductivity probe) of up to ~900 mS/m at ~2.5 m depth, and EC 1:5 values up to ~ 4000 µs/cm (Jones *et al*. 2003), the highest values encountered during project drilling. It is interpreted that the very low elevation of the area means that the water table is very shallow, resulting in build up of salinity due to evaporation/evapotranspiration of groundwater.

The third area of high conductivity corresponds to areas of very low-lying marsh adjacent to Lake Alexandrina (Figure 18). Shallow groundwater in this area is very saline (see Section 7.8 below).

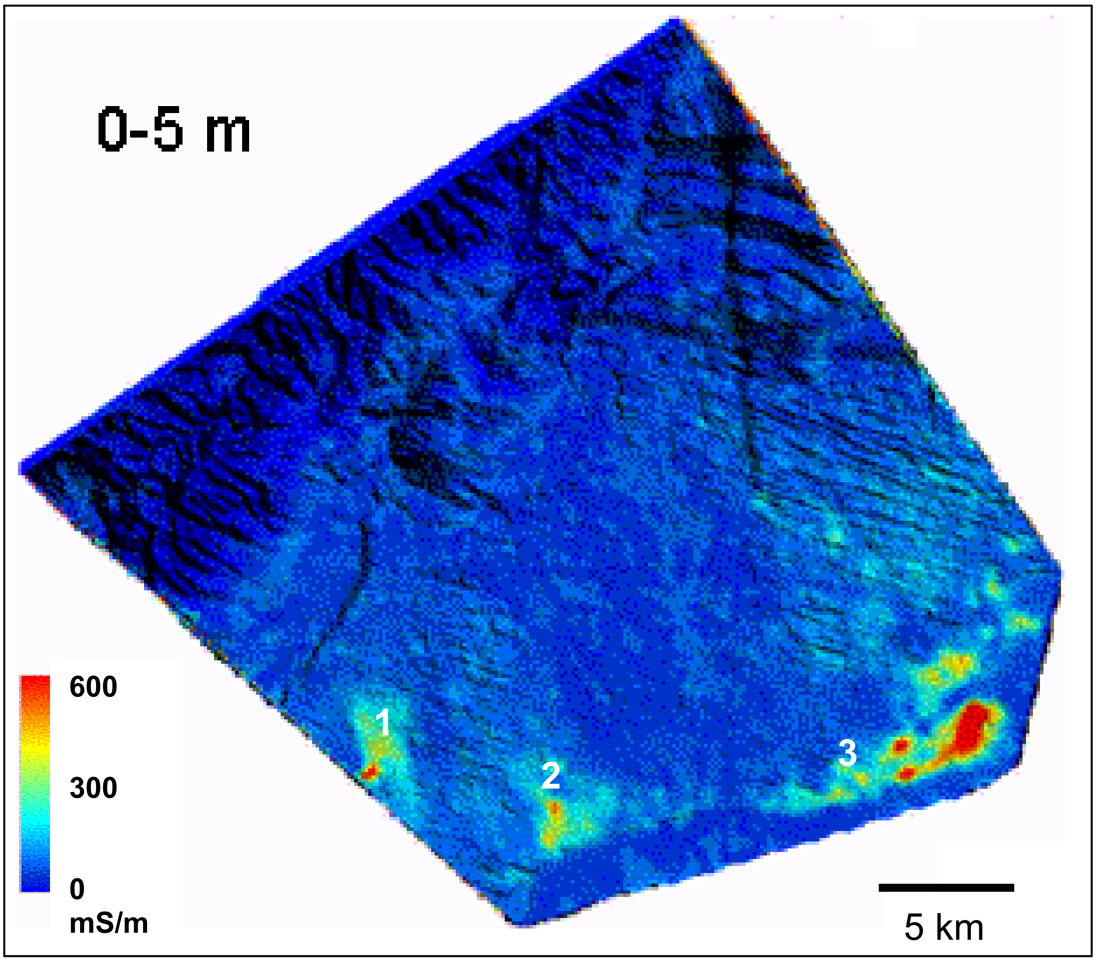


Figure 16. 0-5 m depth AEM CDI slice, 0-600 mS/m linear colour stretch, over greyscale DEM with illumination from the northeast, showing shallow conductivity anomalies. Probable causes of the three numbered anomalies are given in the text.

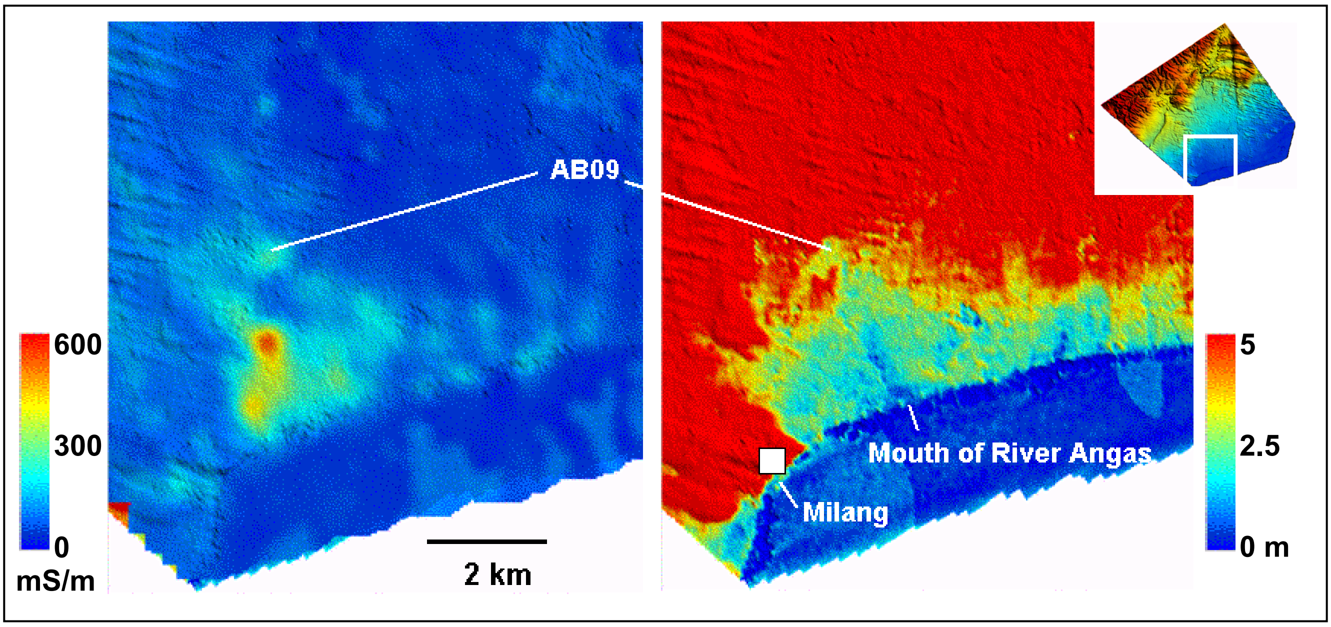


Figure 17. Shallow CDI conductivity (0-5 m depth) over greyscale DEM with illumination from the northeast, and DEM (note colour stretch from 0 to 5 m) near Milang, showing areas of high conductivity corresponding with areas of very low elevation near the mouth of the River Angas, and location of project drill hole AB09 which encountered very high conductivity at ~2.5 m depth (Jones et al. 2003).

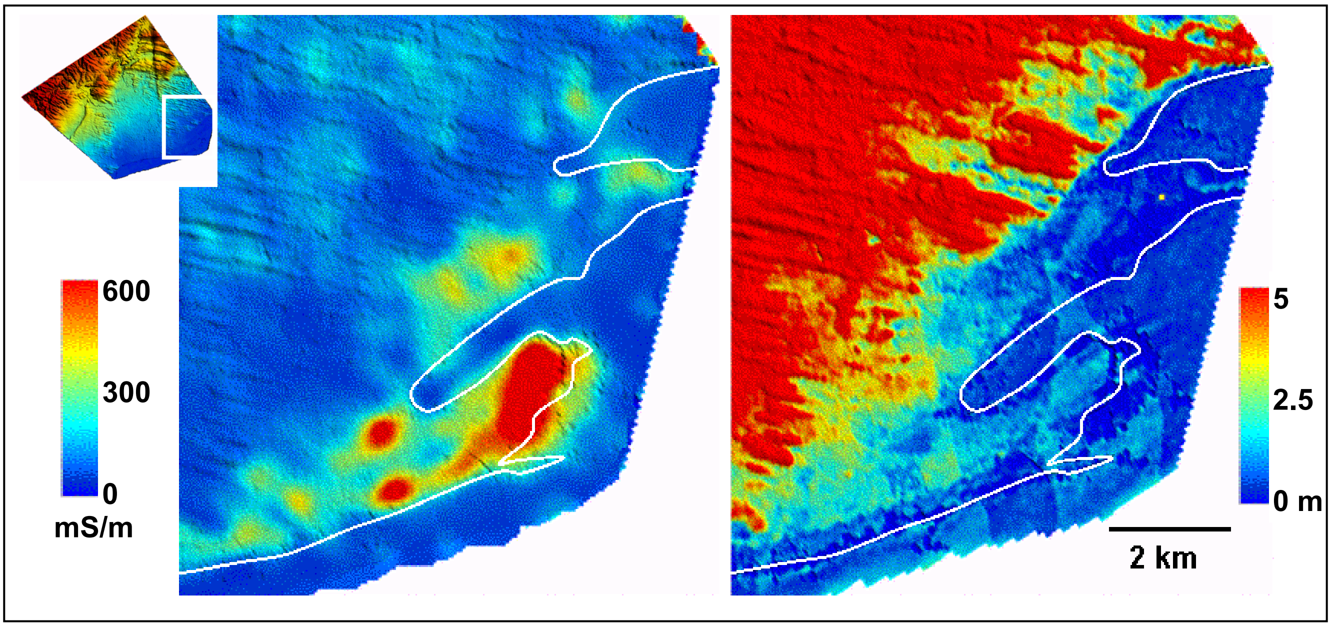


Figure 18. Shallow CDI conductivity (0-5 m depth) over greyscale DEM with illumination from the northeast, and DEM (note colour stretch from 0 to 5 m) in the southeast of the area, showing areas of high conductivity corresponding to low lying marsh areas. Approximate coastline (from 1:250 000 topographic map) shown by white line.

5.3 Magnetics

The newly flown survey, flown with 100 m line spacing, parallel with the northwest margin of the area, shows considerable detail in the magnetic structure of the area (Figures 6, 19). One of the aims of the survey was to determine whether magnetic palaeochannels within the Quaternary sequence beneath the Angas Bremer alluvial plain could be mapped. Potentially these could then be targeted for pumping to lower shallow water tables. There are reports in the literature of maghemite grains and clasts in the alluvial deposits, and locally magnetic ferruginous sand grains and pebbles have been observed in near surface alluvium. Maghemite-bearing gravels are known to show as dendritic anomalies in magnetic images from various areas across Australia (eg Gibson & Wilford 2002; Lawrie et al. 2000; Wildman & Compston 2000; Gidley 1981; Ford 1996). However, from examination of the magnetic images, it appears that magnetic clasts are not sufficiently concentrated in the alluvium to give a clear magnetic signature.

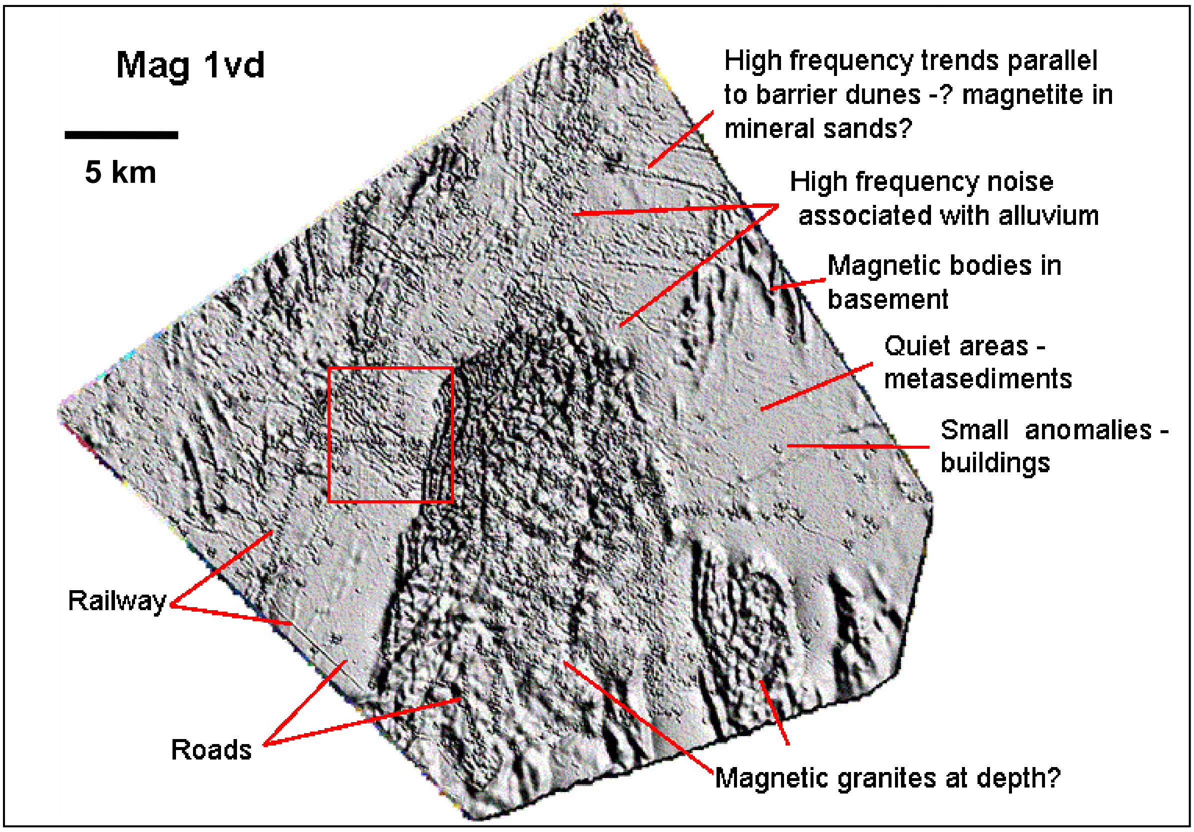


Figure 19. First vertical derivative of airborne magnetics, showing various features. The area of the red box is shown in Figure 20.

The total magnetic intensity image (Figure 6) is dominated by several large basement anomalies that are most probably intrusives (eg granite, see discussion in Section 3.1). The largest magnetic body appears to be cut by several northeast-trending faults (which may be related to the intrusion of the body), and may be shallower at its northern end as the apparent detail within the anomaly is sharper in the north. Smaller anomalies in the northeast of the area are most probably small intrusions of pyroxenite/peridotite (see Section 3.1). Other basement anomalies have not been examined here.

The first vertical derivative (vd1) (Figure 19) shows many short wavelength features across the area. Many of these can be attributed to buildings (steel roofs, machinery etc), roads (use of slightly magnetic road base/aggregate) and railways. The alluvial plains within the study area have a 'noisy' short wavelength magnetic signature (generally around 1 nanoTesla (nT) amplitude), most probably due to disseminated magnetic minerals within the alluvium, and some of the gullies draining the eastern Mt Lofty Ranges have a magnetic signature (i.e. detrital magnetic minerals in narrow tracts of valley floor alluvium). There are no coherent anomalies that can be interpreted as possible channel gravels in the main alluvial plain area, such as are present in the Jamestown study area (Wilford 2003). However, one magnetic gravel body has been identified from the 1vd, about 5 km southeast of Strathalbyn, in the upper confined part of the alluvial plain of the River Angas. Here, a linear (about 1.5 km long) short wavelength anomaly of about 8 nT has been intersected by drill hole 6627-8161 (exploration drill hole 82MB12RM1, Appendix 5), which penetrated highly magnetic gravel at the base of the alluvial sequence (Figure 20). The area between Sandergrove Creek and the Angas Bremer alluvial plain does not display short wave length anomalies, suggesting that the older Quaternary sediment cover across this area (see below) lacks detrital magnetic minerals.

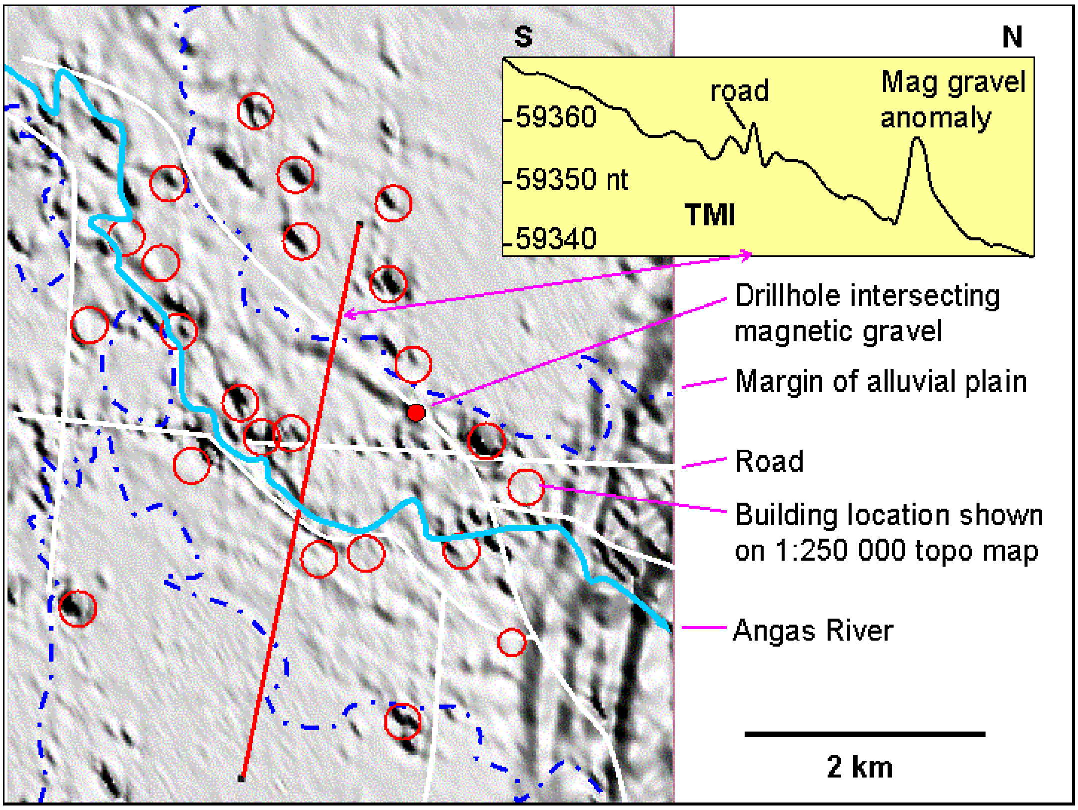


Figure 20. Detail of first vertical derivative of magnetics (greyscale with illumination from NE) showing an anomaly due to magnetic gravel in Quaternary alluvial sediment. The magnetic profile in the yellow box is along the red line. Gridding between flight lines results in small features appearing to have a northwest orientation. See Figure 19 for location.

There are some diffuse short-wavelength anomalies in the north of the area, parallel to the trend of the barrier dunes. These anomalies could represent concentrations of heavy minerals within the Pliocene barrier dune sequence (Figure 19).

5.4 Radiometrics

The radiometric coverages (radioelements K, U and Th; Figure 21) provide detail about the distribution of surface materials. The responses from the three radioelements are roughly proportional to each other across most of the area, especially K and Th (Figure 22). Thus the distribution of K or Th as a single channel pseudocolour image is in many places more useful in showing variations in the radioelement content of surface materials than a traditional red/green/blue ternary image. The U channel is noisier than, and not as useful as the other two. Fresh basement rocks and their locally derived soils and alluvium have high response in all channels, although there are minor variations that are dependent on landscape position. These variations may reflect factors such as soil texture which can be landscape dependent.

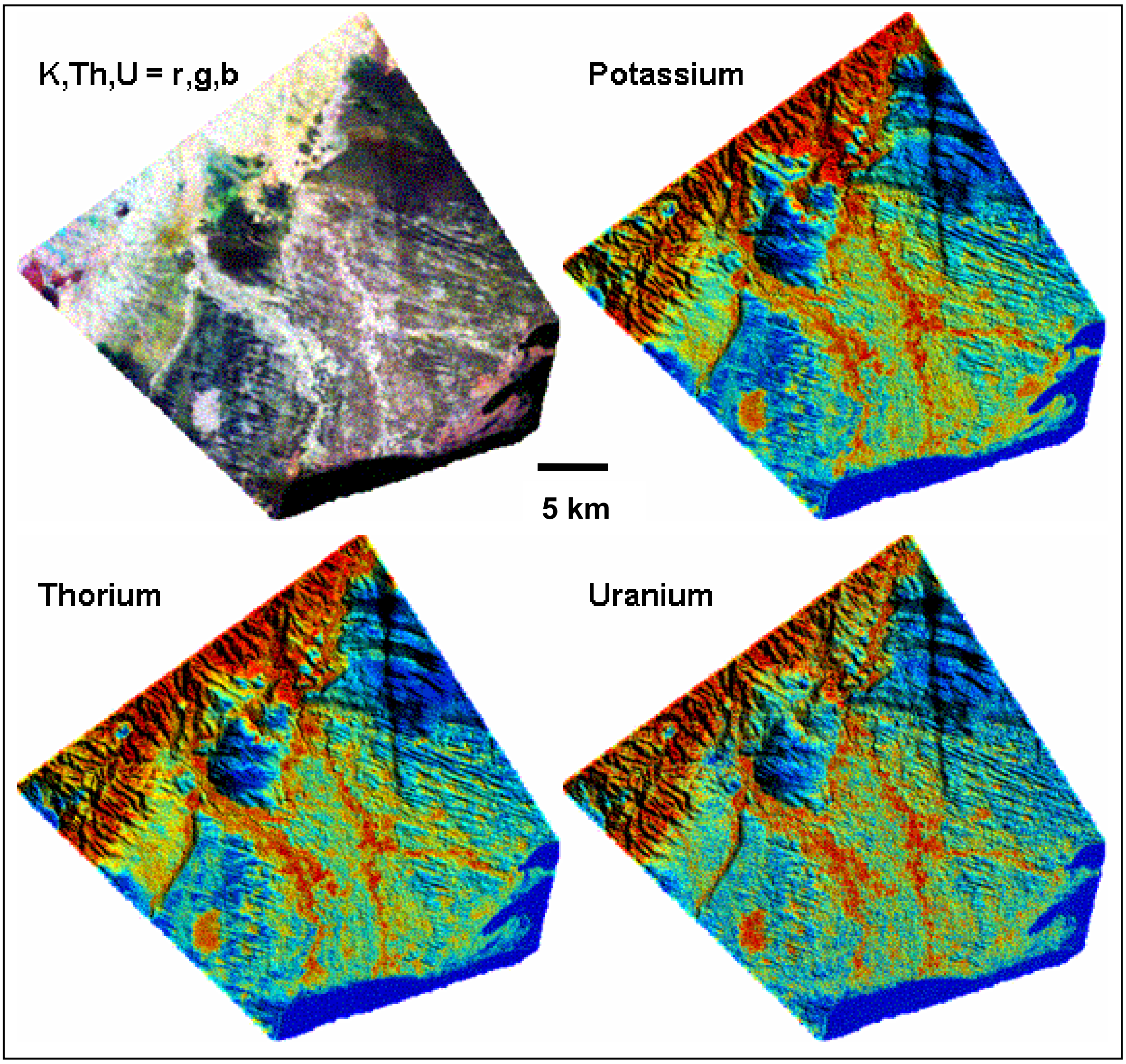


Figure 21. Thumbnails of radiometric images. The K, Th and U channel data are overlain over greyscale DEM with illumination from the northeast.

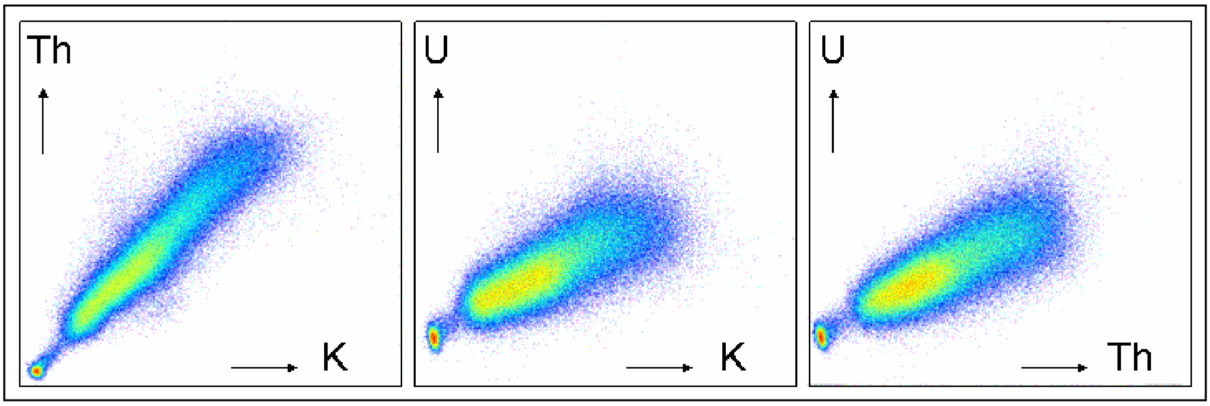


Figure 22. Cross plots of radiometric intensity point data, showing strong correlation between potassium and thorium responses, and lesser correlation between uranium and the other two elements. Colour (red to blue) is proportional to the density of the point data. The small bullseyes near the origin of each plot correspond to points on water (Lake Alexandrina) which have minimal radioelement response.

A radiometric low in the far west of the area corresponds with a known area of mapped Permian sediment. Some smaller local lows correspond with hilltops previously mapped as having weathered basement or ferruginous materials (remnants of the "lateritised" summit surface of the Mt Lofty Ranges). Other ridge top lows suggest the presence of previously unmapped remnants of weathered rock. Known outliers of Tertiary sand and limestone also correspond with radiometric lows. However, there are other radiometric lows that appear to be other previously unmapped Tertiary outliers. These are further discussed in Section 7 below.

Longitudinal sand dunes show as radiometric lows (quartz sand rich), whereas the intervening swales have a variable signature, probably depending on the amount of fine material or moisture present. A large area with high radioelement response southeast of Sandergrove Creek corresponds with an area of clay soils with gilgai as shown on soils maps (DWLBC 2002). The DEM indicates that this area is a window through the aeolian sand cover to the underlying clayey possible Early Quaternary sediment. This is further discussed in Section 7.5

The Angas Bremer alluvial plains and the alluvial fans west of Sandergrove Creek show highly varied response. High response areas appear to correspond with areas of silty overbank alluvium either deposited on levees or in low lying areas between slightly raised sandy areas (source bordering dunes, sand sheets etc) with low response. See section 7 for further discussion.

The radiometrics appear to be a very useful tool that can be used for detailed soil mapping across the entire study area..

5.5 Ground EM

Three ground EM (Nanotem) lines were carried out as part of the project; their locations are shown in Figure 4. Lines one and two were measured by CSIRO Exploration and Mining, and line 3 by Zonge Engineering and Research Organization (Australia) Pty. Ltd. Inversions of the lines are shown in Figure 23. The lines were done to provide a check on the AEM CDIs in areas where drilling was planned, and help locate drill targets. Overall, the lines show conductivity structure similar to the gridded CDIs, although absolute conductivities do not necessarily match, a function of the inversion procedures used. Specific features targeted by drilling include:

1. A buried area of high conductivity at about 15 m depth at the western end of line 1. This was tested by project drill hole AB07 (at station 160) and found to be conductive weathered basement (Appendix 12; Jones *et al*. 2003).
2. A large area of moderate conductivity below 30 m depth in central to eastern line 1. This was tested by AB05 (near station 5855) and found to be Tertiary limestone containing fresh water.
3. A shallow area of high conductivity in the middle of line 2, tested by AB09 (316897 m east) and found to be highly conductive Quaternary sediment (conductivity as measured by wireline logging up to ~850 mS/m). The anomaly coincides with an area of extremely low topography and shallow water table, and it is considered likely that this may at times be a discharge zone (through evapotranspiration) where salt is concentrating.
4. Conductors in the western part of line 2, tested by AB10 (315510 m east) and found to be Tertiary limestone with salt water
5. Relatively deep conductors in the western half of line 3, tested by AB02 (at station 2345) and found to be Tertiary limestone and younger sediments with saline water.
6. Resistor in the middle of line 3, tested by AB03 (along strike from station 3325) and found to be shallow basement.
7. Deepening conductor in the eastern half of line 3, tested by AB04 (at station 4485) and found to be unsaturated Tertiary limestone.

Further interpretation and inversion constrained by downhole geophysical logs has not been carried out on the ground EM lines as part of this project.

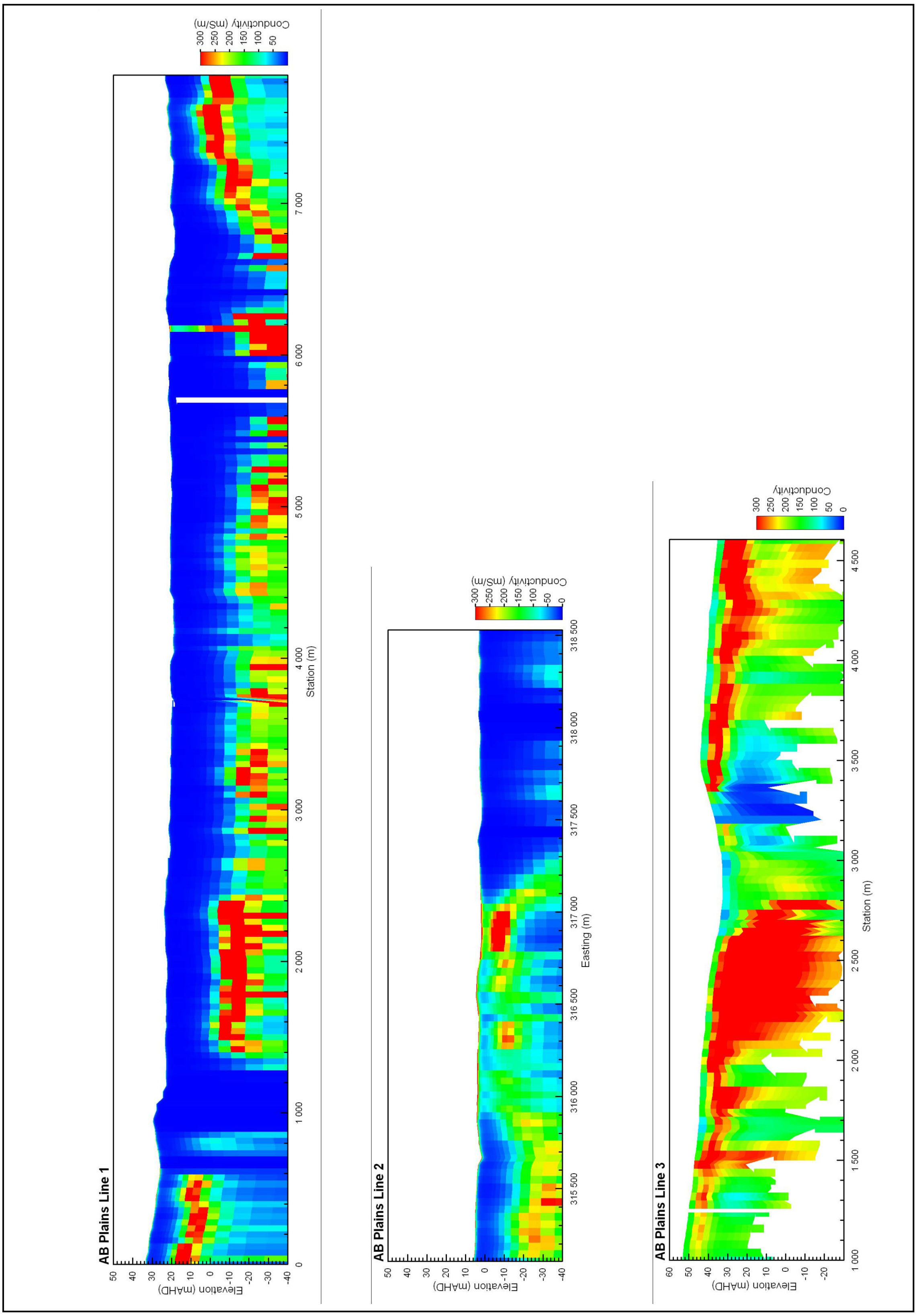


Figure 23. Thumbnails of Nanotem lines, draped on topographic profiles.

6. STRUCTURE AND GEOMETRY OF CENOZOIC SEDIMENTS

6.1 Faults

Three faults that have offset Cenozoic materials are recognised in the area. These are described below and shown on Figure 24. McPharlin (1973) and Williams (1978) postulated an extension of the Encounter Bay Fault into the area, but the AEM data do not show offset of Cenozoic materials in the area proposed by these authors.

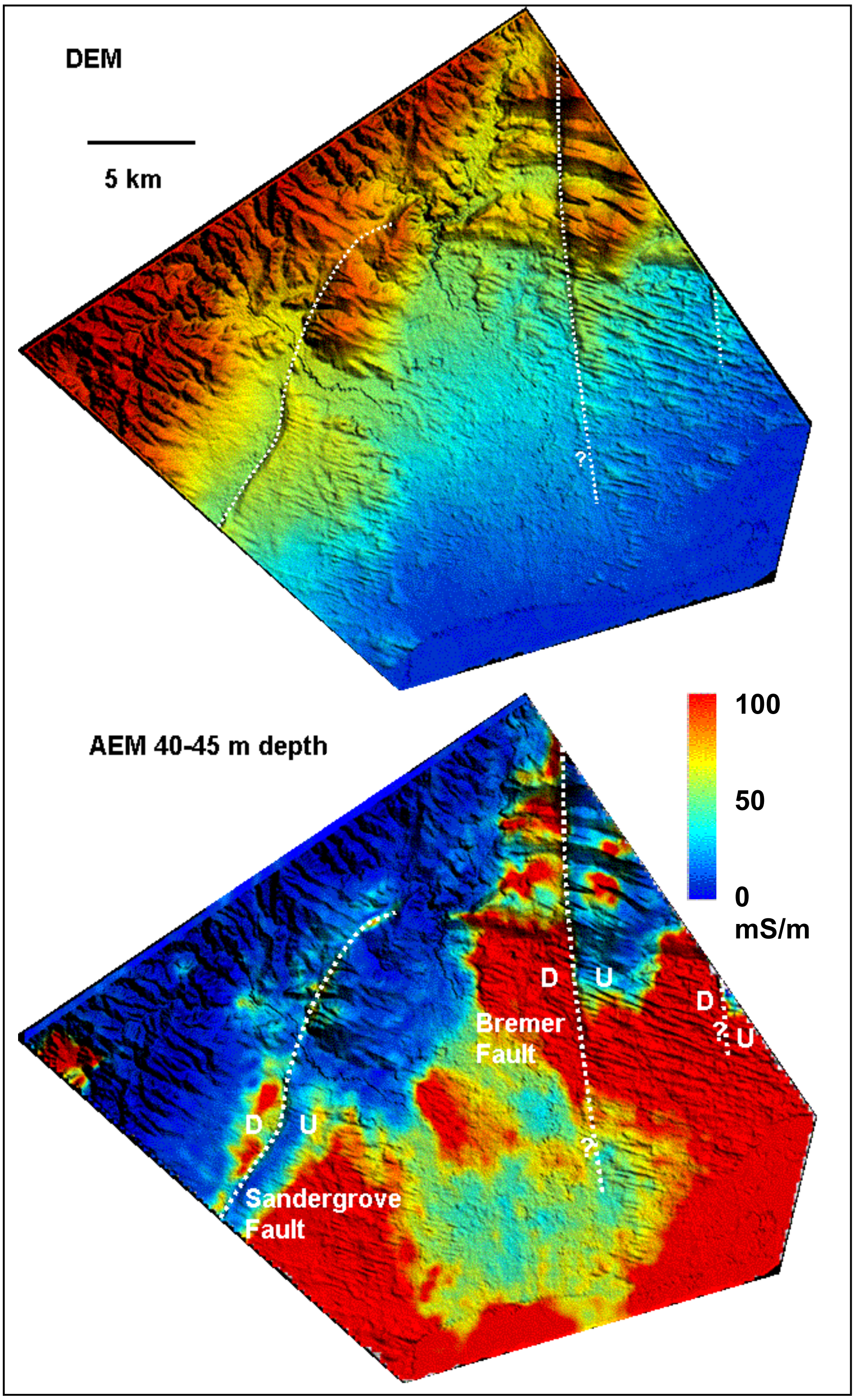


Figure 24. Faults that have offset Cenozoic materials, shown over shaded radar DEM, and over 40-45 m AEM depth slice (0-100 mS/m linear colour stretch to accentuate changes in conductivity across the faults) with shaded DEM.

6.1.1 *Bremer Fault*

The Bremer Fault, depicted on geological maps to the north, extends southwards into the area. It is characterised by a surface lineament consisting of aligned west-facing scarps and apparent west-side down offsets of ridges (see oblique view of DEM, Figure 3). AEM and drill data suggest that offset of the basement/sediment unconformity is highest in the north of the study area (up to 80 m, west side down), decreasing to a probable minor offset in the south. The signature of the fault in AEM data cannot be traced further south than Langhorne Creek and to the south of this point there are no holes to basement on the immediate eastern side of where the fault probably runs to confirm depth to basement. The offset of the basement-sediment contact is the sum of all movement since deposition commenced, probably in the Eocene/Oligocene, whereas the apparent offset of landscape probably represents only recent movements. The DEM shows that some valleys west of the fault in the north of the area (which superficially appear to drain westwards towards the Bremer River) have areas of internal (endoreic) drainage (see Section 7.6). It is probable that this results from downwarping of landscape on the western side of the fault, causing reversal of drainage direction. The observed conductivity data at the fault shows sharp contrasts along a narrow zone which does not migrate with depth. This indicates that the sediment/basement interface is a near vertical plane, rather than a shallowly inclined surface that would be expected if the movement predated sedimentation, and sediments were deposited against an eroded fault scarp. The Bremer Fault has faulted the Tertiary limestone aquifer against basement, and may influence the local movement of groundwater.

6.1.2 *Un-named fault in the east of the area*

A low linear west-facing scarp in the DEM coinciding with a sharp north-trending boundary between conductor (west side) and resistor (east side) in the AEM data suggest a fault parallel to and about 7 km east of the Bremer Fault. This fault appears to extend only a short distance into the study area, but drill data suggest it has offset basement (west side down) by 40-60 m where it crosses the edge of the study area. There is no landscape expression of a continuation of this fault north of the study area apparent on 1:50 000 airphotos It is thus possible that Cenozoic movement postdated deposition of Eocene-Miocene sediments, but mostly predated the deposition of the Pliocene barrier dunes Basement outcrops shown on the Mobilong (Johns 1960) and Alexandrina (McGarry 1958) geological maps around 332000 6097500 (just outside the study area) are on the eastern side of this fault, whereas drill hole 6727-2517 about 2 km west of the outcrops and on the west side of the fault intersected 60 m of Cenozoic sediment (Appendix 5).

The stratigraphy of drill hole 6727-2238 (FRL143) on the eastern (upthrown) side of this fault was studied in detail by Lablack (1991). She found that the Miocene Mannum formation was missing between the Quaternary sediments and the Oligocene Ettrick Formation equivalents. The detailed lithology recorded for hole 6727-2517 (KR9202) (Appendix 5), drilled ~ 1 km west of the fault at the edge of the study area indicates presence of graphitic pyritic dark blue limestone from 52-60 m, overlying Palaeozoic basement. This lithology contrasts with the yellowish calcarenite with quartz grains that makes up much of the Ettrick and Mannum Formations. Small surface fragments of fine grained grey limestone are present ~1.5 km east of the fault at 332095 6097434, in an area of polygons of basement and Tertiary sediments on the Alexandrina 1 Mile Geological Sheet (McGarry 1958). The limestone is not basement limestone (which is present only as marble in this region, Malcolm Sheard, PIRSA, pers comm. 2003). It is slightly porous, and appears to be peloidal. It is similar to the limestone at the base of 6727-2517 (see above), and the inference is that this basal limestone lithology has been offset to be near the surface east of the fault.

There are other possible explanations for the presence of basement/grey limestone outcrop/subcrop ~2 km east of 6727-2517 where sediment is 60 m thick. There may be a buried basement hill or tilting of an originally flat-lying unconformity, but these possibilities are not supported by the AEM data. Thus it is interpreted that the area east of the fault has been uplifted since Oligocene-Miocene deposition, and the upper (Miocene) part of the sediment eroded prior to Quaternary deposition.

6.1.3 *Sandergrove Fault*

The Sandergrove Fault (new name) was recognised during study of airphotos of the area. Sandergrove Creek runs along a fault angle depression at the foot of the scarp. The DEMs show that the fault scarp is up to 15 m high, and has not been incised by drainage lines, implying that the most recent movements are quite young in geological terms. AEM, ground EM line 3 and drill data (particularly project holes AB02, AB03 and AB04; Appendix 12, Jones *et al*. 2003) show that basement has been offset by up to > 50 m, west side down. It is not considered that the scarp is a result of sedimentation against a pre-existing basement ridge, as the AEM data show no incision of the basement surface as would be expected of a buried pre-existing landform. The fault scarp dies out about 3 km southwest of the study area where Sandergrove Creek swings to the east to flow towards Lake Alexandrina, and this is interpreted to be the limit of recent displacement. To the north, the scarp continues to within 3 km of Strathalbyn where it terminates against the confined alluvial plain of the River Angas (Figure 25). It is suggested that as movement occurred on the fault (east side up), the palaeo Angas River eroded through the rising ground to the east of the fault, creating an antecedent valley cut into both uplifted Cenozoic sediment and the underlying basement rocks. This valley has since been partly filled with alluvium, to create the ~1.5 km wide confined alluvial plain that extends for about 8 km downstream from Strathalbyn. The area between the Sandergrove Fault and the lower part of the Angas Bremer alluvial plain is interpreted to be a tilt block resulting from the faulting. The interpreted history of the area (Figure 26) shows fault movements occurring over an extended period, both before and after deposition of ?Early Quaternary continental deposits

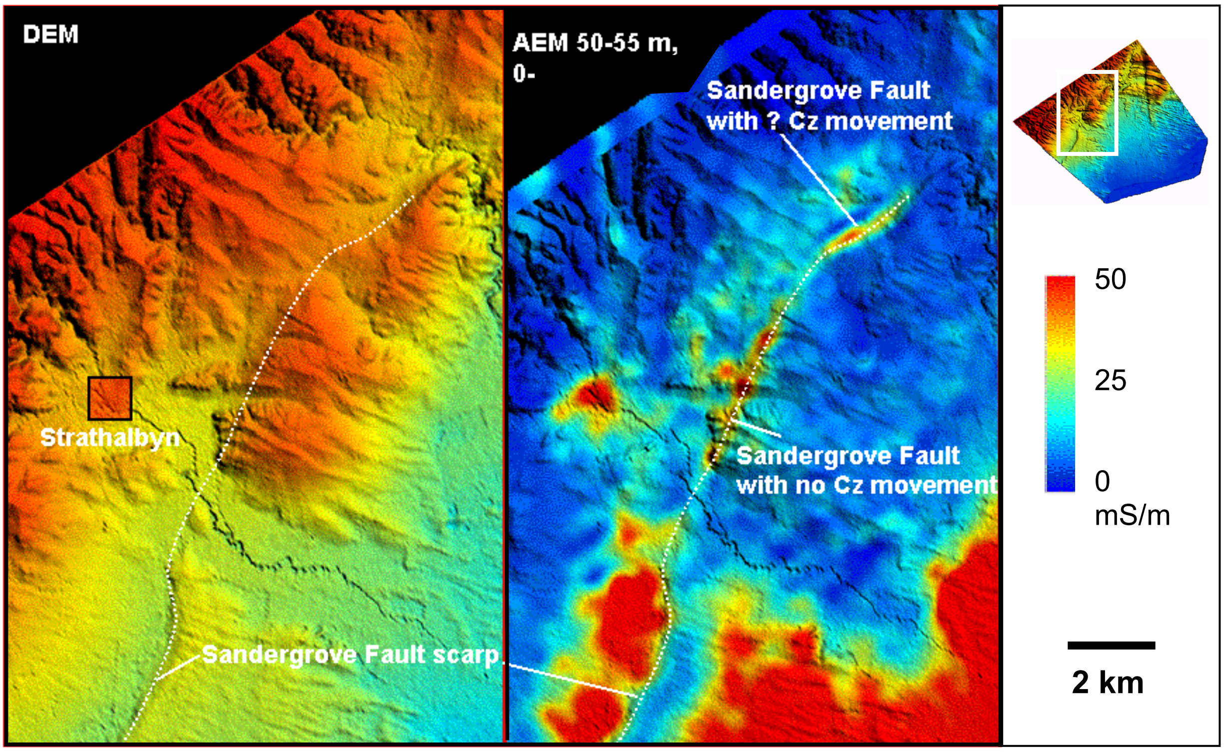


Figure 25. Interpreted location of the Sandergrove Fault around Strathalbyn plotted on Radar DEM and 50-55 m depth CDI slice (0-50 mS/m linear colour stretch) over DEM with illumination from the NE.

North of the alluvial plain of the River Angas immediately downstream from Strathalbyn, there is a narrow zone of anomalous AEM conductivity that extends down past 100 m depth, which aligns with the fault scarp and also coincides with an anomalous northeast-aligned valley (Figure 25). This zone is interpreted as a continuation of the Sandergrove Fault. The conductivity is interpreted to possibly be due to a zone of weathering along the fault, with higher moisture content than the surrounding fresher basement rocks, but there are no drill data to confirm this. The zone passes beneath outcrops of Tertiary limestone east of Strathalbyn at about 311000 6095500 without any apparent offset of the limestone visible in the DEM or on airphotos. However, further north, it is possible the fault may have offset Cenozoic sediments.

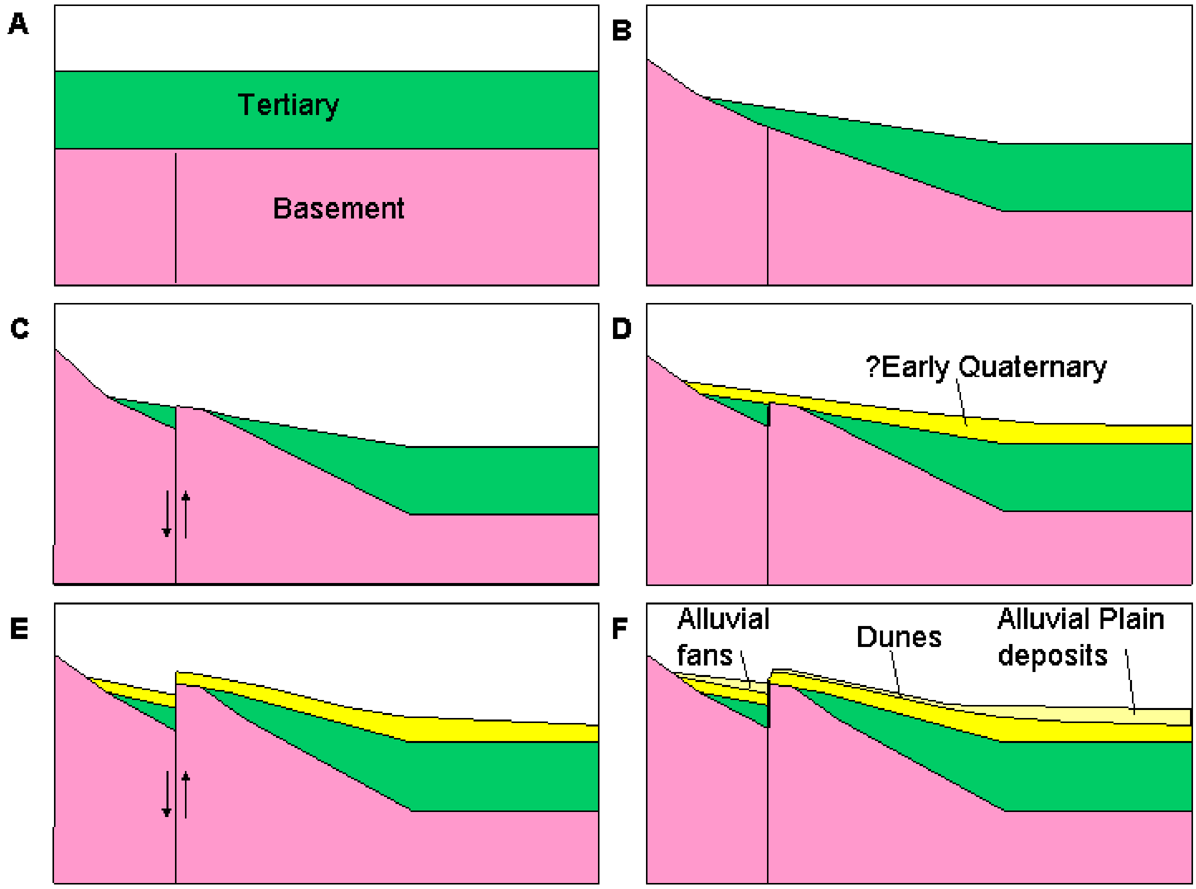


Figure 26. Schematic sections detailing the development of stratigraphy and landscape from eastern Mt Lofty Ranges to the Angas Bremer alluvial plain across the Sandergrove Fault. A. Deposition of marine Tertiary sediments, including limestone. B. Uplift and tilting, with erosion. C. Movement on Sandergrove Fault offsets Tertiary sediment, erosion exposes basement east of fault. D. Deposition of ?Early Quaternary outwash sediment from ranges to west. E. Further movement on Sandergrove Fault offsets Tertiary and Quaternary sediment. F. Further Quaternary deposition west of fault in alluvial fans, and on Angas Bremer alluvial plain in the east. Minor contemporaneous erosion and deposition of veneer of aeolian sand over tilted block. ?Early Quaternary sediment may have been eroded in the east prior to deposition of alluvial plain sediment, but this has not been shown.

South of Strathalbyn Tertiary sediments, including limestone, are preserved west of the Sandergrove Fault. These crop out in rises immediately south of Strathalbyn (see Section 7.3 below), but are buried by younger sediments further south. A basement high is present east of the fault, as shown by project drill hole AB03 (Appendix 12), outcrops of basement in the bed and banks of the Angas River at about 310600 6093900 (see Figure 69), and AEM data. In addition, a local landowner (Neville Vivian, pers. comm., 2003) found basement rock intersected in an auger hole dug for a power pole near his house, at about 310600 6093300, about 600 m south of the basement exposures in the river. A zone of shallow CDI conductivity suggest that the sediments continue northwards in a zone west of the fault, crossing beneath the Angas River between the limits of mapped basement outcrops at about 310000 6095600 and 310600 6094000 (Milang One Mile Sheet, Horwitz & Thompson 1960) and continuing to the north-northeast (Figure 27). Bore 6627-5774 (311659 6097668, elevation ~ 81.6 m) in the area of higher conductivity north of the Angas River intersected 26.5 m of sand and gravel (driller's log, Appendix 7), which is interpreted to be a continuation of Tertiary sand, silt and gravel exposed beneath Tertiary limestone in pits near Strathalbyn at ~ 310960 6097231 (about 800 m distant), with some possible Quaternary reworked material near the top of the section.

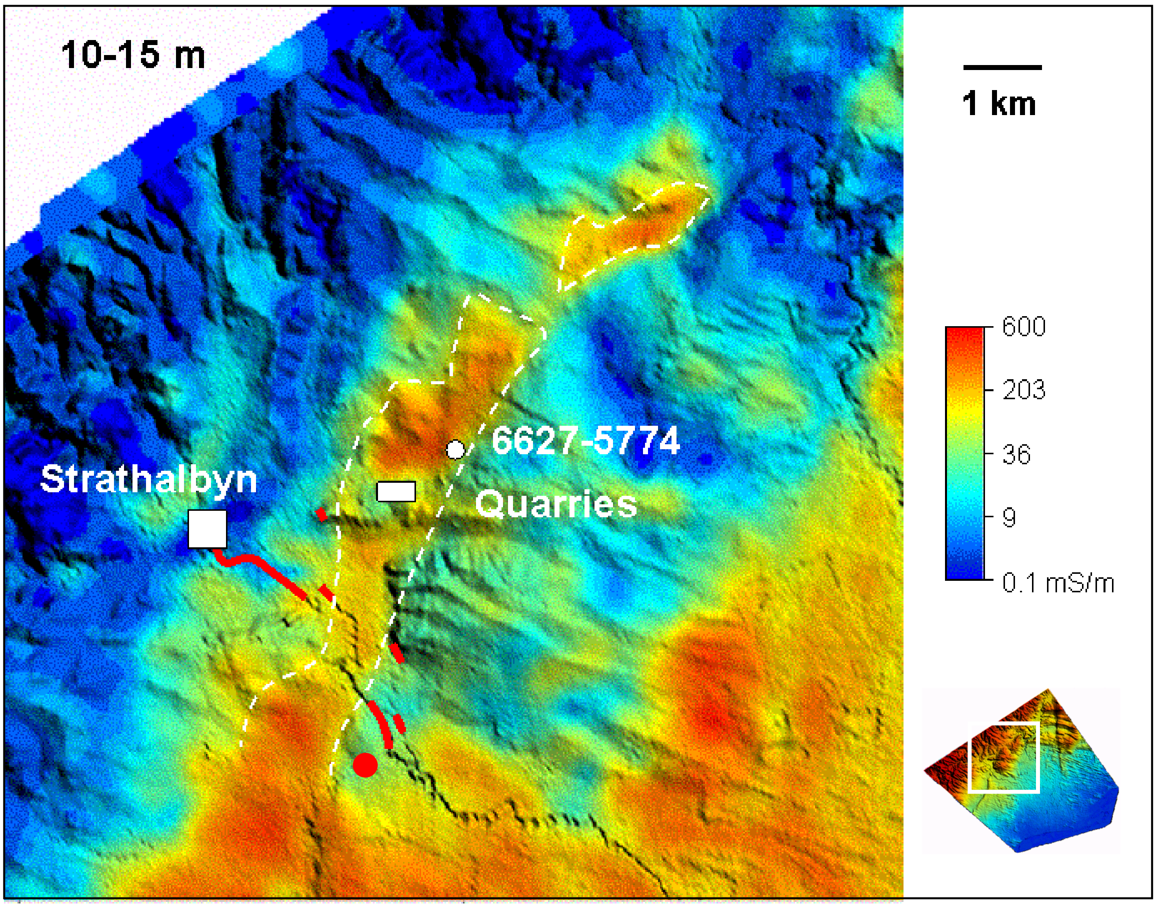


Figure 27. 10-15 m depth CDI slice with logarithmic colour stretch (0-600 mS/m) over shaded DEM, annotated to show interpreted areas of thicker Tertiary sediment (enclosed by dashed white line), basement outcrops southeast of Strathalbyn as shown on the Milang 1 mile sheet (red lines) and in auger hole (red dot), bore 6627-5774 (intersected 26.5 m of sand and gravel over basement) and quarries exposing ~ 6m of Tertiary ?estuarine sand, silt and gravel (base not exposed) beneath Tertiary limestone. The interpreted areas of sediment are bound to the southeast by the Sandergrove Fault.

This area of sediments could result either from movement along the Sandergrove Fault preserving sediment on the downthrown (western) side, or preservation of the sediments in a palaeo valley which was eroded along the fault prior to deposition. Outcrops of limestone in the area of the fault do not appear on airphotos to be faulted, so the latter explanation is favoured.

6.1.4 Encounter Bay Fault

McPharlin (1973) and Williams (1978) used resistivity soundings and drill hole intersections to postulate a NE-SW oriented zone of relatively rapid basement shallowing across the northwest part of the Angas Bremer alluvial plain and the interpreted tilted area between Sandergrove Creek and the alluvial plain. This was interpreted as a major fault which controlled the preserved northwest margin of the Tertiary limestone, and was considered to be a possible extension of the Encounter Fault (Firman 1973), which has been mapped to the southwest of the study area. The location of McPharlin's fault is approximately plotted on Figure 28, along with approximate elevations of the base of the sediments in drill holes. From the data presented, it is clear that there is a zone where the elevation of the unconformity rises more steeply than either further basinward, or further to the northwest. However, the steepest gradient, from 93 m to 7 m below sea level over about 2 km (along the Angas River about 10 km southeast of Strathalbyn) is equivalent to a dip of only 2.5° if entirely due to tilting or original slope on the unconformity surface, with no fault displacement.

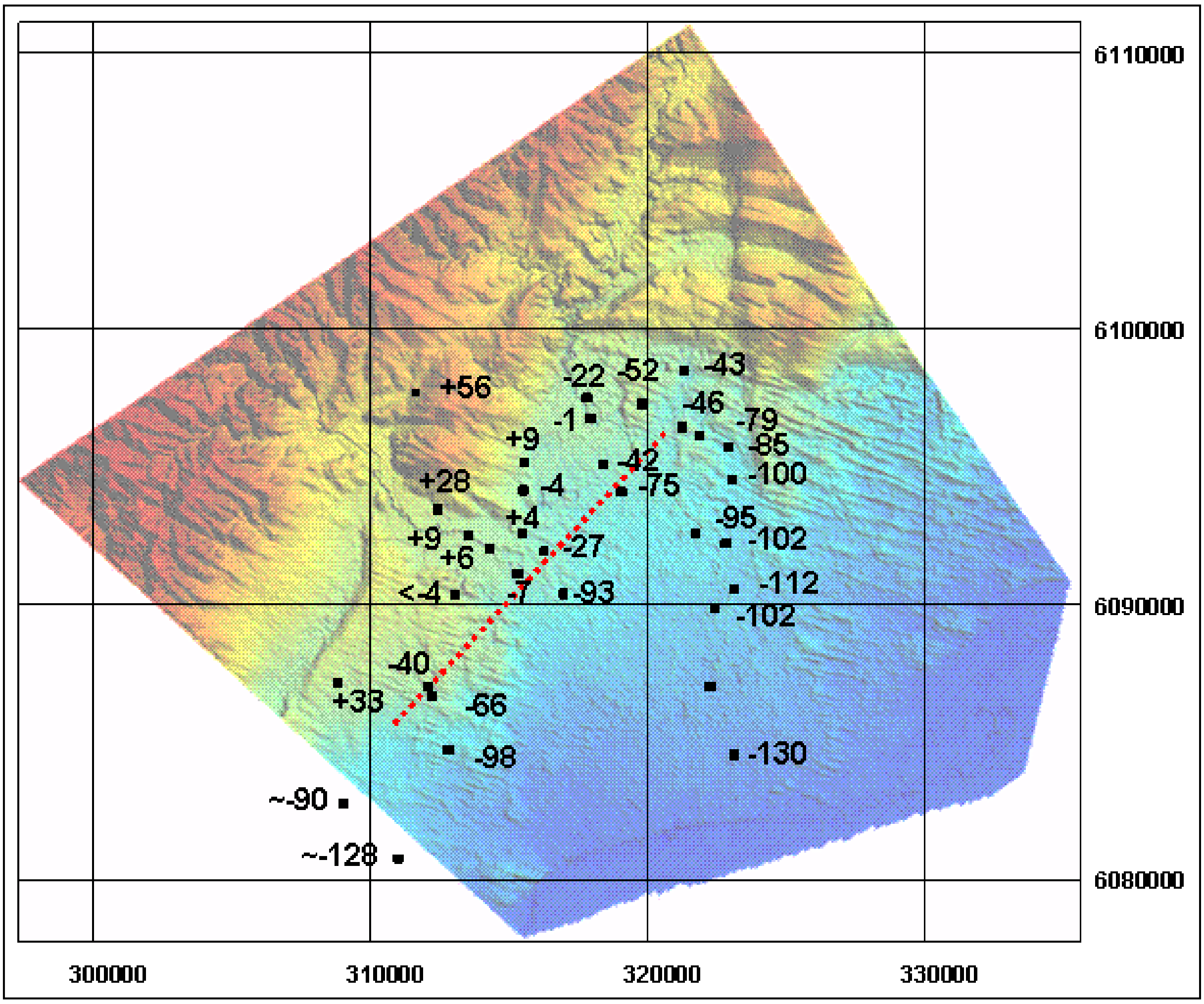


Figure 28. Shaded radar DEM with the approximate location of McPharlin's proposed fault (from resistivity soundings, dotted red line) and elevation of the basement/sediment contact (Appendix 9) in drill holes around the proposed fault. Elevation in two holes to the southwest of the area is considered to be ± several metres as ground elevation is not well constrained.

Illustrations in McPharlin (1973) show that he considered the fault to lie at the point where basement elevation started to rise relatively rapidly. He states "..it must be suggested that considerable erosion took place contemporaneously with movements along this (fault) line", based on the observation that there is not a sudden offset in basement at the proposed fault, but rather a gradual increase in elevation of the unconformity to the northwest. Also he suggests "…some movement within the sediments along this (fault) line may have taken place allowing easier ingress of river water at this point…" Thus he implies that movements along the fault controlled the palaeo topography of the area prior to deposition of the limestone, forming a fault scarp, which after erosion formed a zone of steeper basinward slope against which the limestone was deposited. He also implies that there has only been limited fault movement since sediment deposition. An interpretation of McPharlin's statements is summarised diagrammatically in Figure 29.

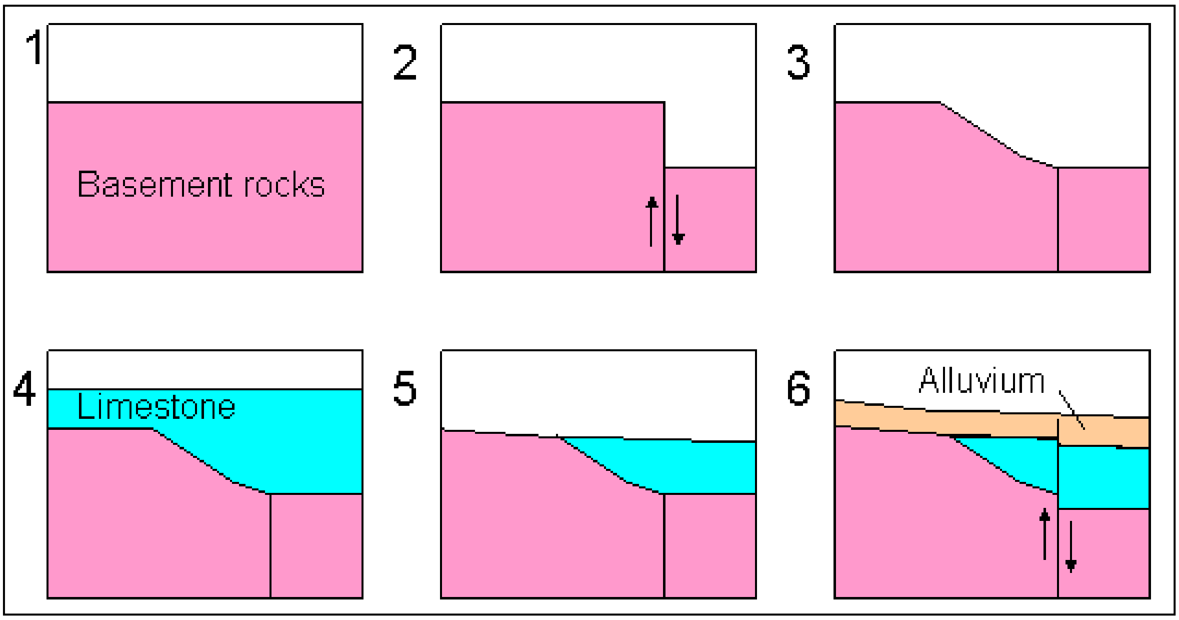


Figure 29. Sketches of the sequence of events as described in words by McPharlin (1973) at the "faulted basin margin". 1 & 2. Faulting of basement prior to Tertiary deposition to form a fault scarp. 3. Erosion of scarp (2 and 3 may be contemporaneous over a period of time). 4. Deposition of Tertiary limestone and other sediments. 5. Erosion of Tertiary sediments and basement. 6. Deposition of alluvium, and possible further fault movement.

The geometry of proposed fault location with respect to rapid increase in basement elevation is different from that shown on various later cross sections of the area (eg in S.A. Barnett 1994; Howles 1994; Telfer *et al.* 2000). These authors show the fault to be to the northwest of the zone of rapidly rising basement, and to the northwest of the margin of the limestone where it pinches out in the subsurface between basement and overlying sediment (Figure 30a). Although it is described as the "faulted margin of the basin", the fault is not actually shown intersecting Murray Basin sediments. In contrast, Waterhouse (1977b) shows the fault actually terminating the limestone (Figure 30b).

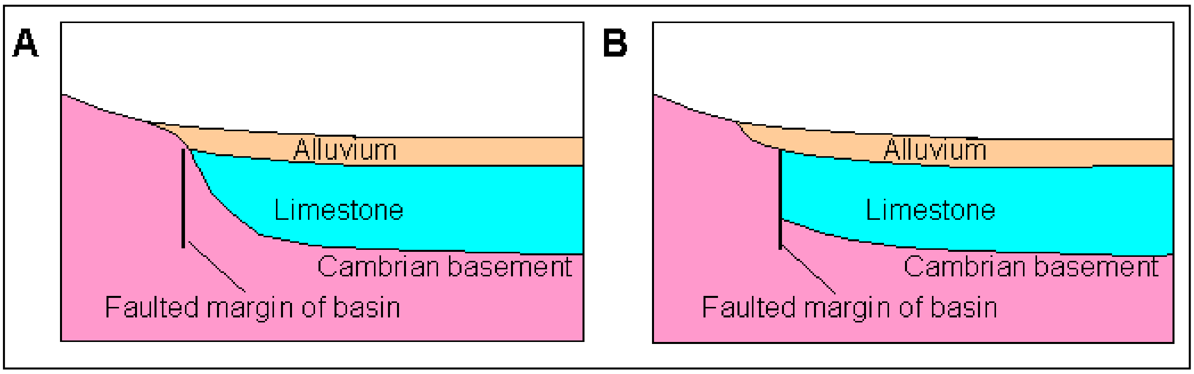


Figure 30. Previous interpretations of the geometry of the "faulted basin margin". A. After Howles (1994). B. After Waterhouse (1977b).

It is expected that recent movements, if any, would be reflected in offsets or low scarps in the alluvial plain, but detailed study of the DEM and airphotos reveals no features that might relate to this proposed fault.

It is suggested that the shallowing basement in the area of McPharlin's proposed fault is mostly due to warping related to uplift of the Mt Lofty Ranges during the late Tertiary and Quaternary (eg Tokarev *et al*. 1998: Tokarev & Gostin 2004), possibly associated with fault displacements at depth. The warping raised sediment in the western part of the Murray Basin, leading to its erosion to expose basement in the Eastern Mt Lofty Ranges. Small outliers of this sediment are still locally preserved in this area at elevations of up to ~ 150 m (see Section 7.1 below). This concept is summarised in Figure 31.

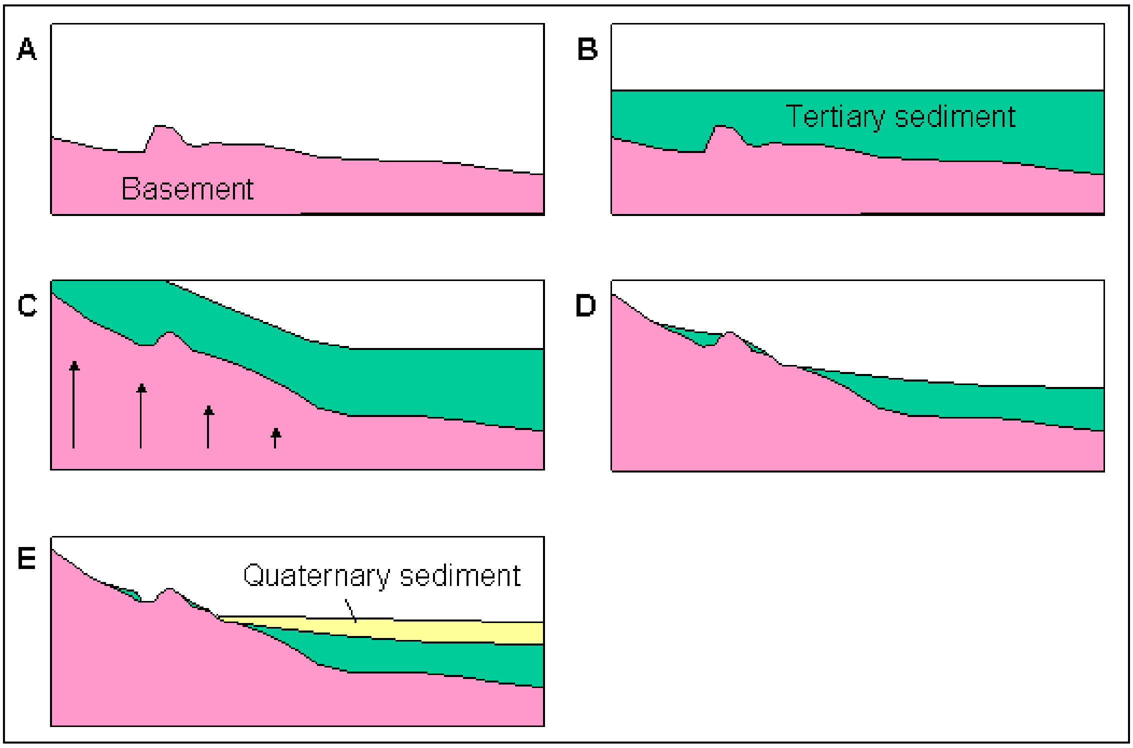


Figure 31. Schematic sections for the geological development at the margin of the Murray Basin in the area, based on section C-M (Figure 35). A. landscape prior to Tertiary sedimentation. B. deposition of Tertiary sediments. C. Tilting due to uplift of Mt Lofty Ranges. D. erosion. E. deposition of Quaternary sediments, further erosion at higher elevations.

Twidale & Bourne (1975) suggested that different elevations of the sediment/basement contact may reflect the original topography during deposition. Under this model, there has been no or only minor tectonic deformation of the Murray Basin sequence, and the high level Eocene to Miocene sediments were deposited in shallow water, whereas the material at lower elevation was deposited in deeper water. This model does not account for uplift of the Mt Lofty Ranges which must have had an effect on the elevation of the limestone at least at the margins of the ranges. There may have been some local palaeo topography, as suggested in Figure 31. Detailed palaeogeographical reconstruction could be carried out using fossils in the Tertiary sediments to determine depth of water during deposition, thus helping to understand amounts of differential movement, but this is outside the scope of this study.

Several possible basement faults can be interpreted from the magnetics in the vicinity of the area where basement elevations begin to rise, and it is possible that these have influenced the locus of the hinge zone at the edge of warping (two of these are shown in Figure 32). The interpreted fault of McPharlin (1973), which probably represents a hinge zone, lies close to these basement faults.

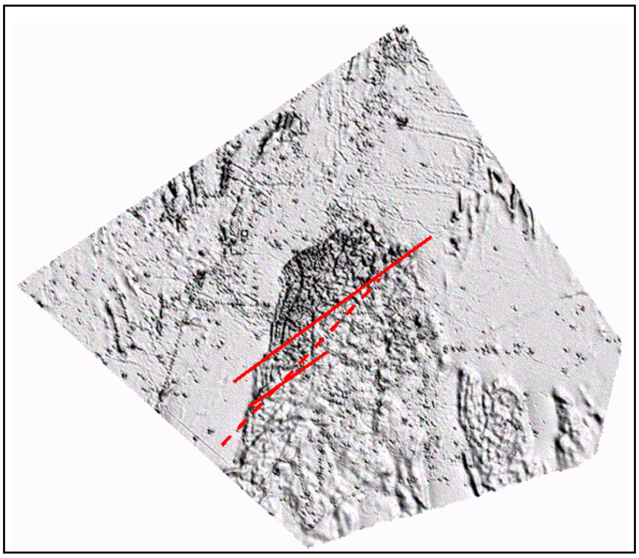


Figure 32. First vertical derivative of magnetics showing two possible basement faults (solid red lines) and approximate location of the fault proposed by McPharlin (1973) (dashed red line).

6.2 Basement structure contours

The locations of structure contours of the base of the sedimentary section (Figure 33) were constructed using the method described in section 5.2.3. They are also available as spreadsheet files of grid references of points along the contours. They are least accurate where the conductivity of the sediments is low, i.e. beneath much of the Angas-Bremer alluvial plain. They have been estimated down to -100m. Lowest elevation of the contact in drill holes is -130 m (6727-1527, Appendix 9), but as this is the only point with elevation below 120 m, the -120 m contour has not been attempted.

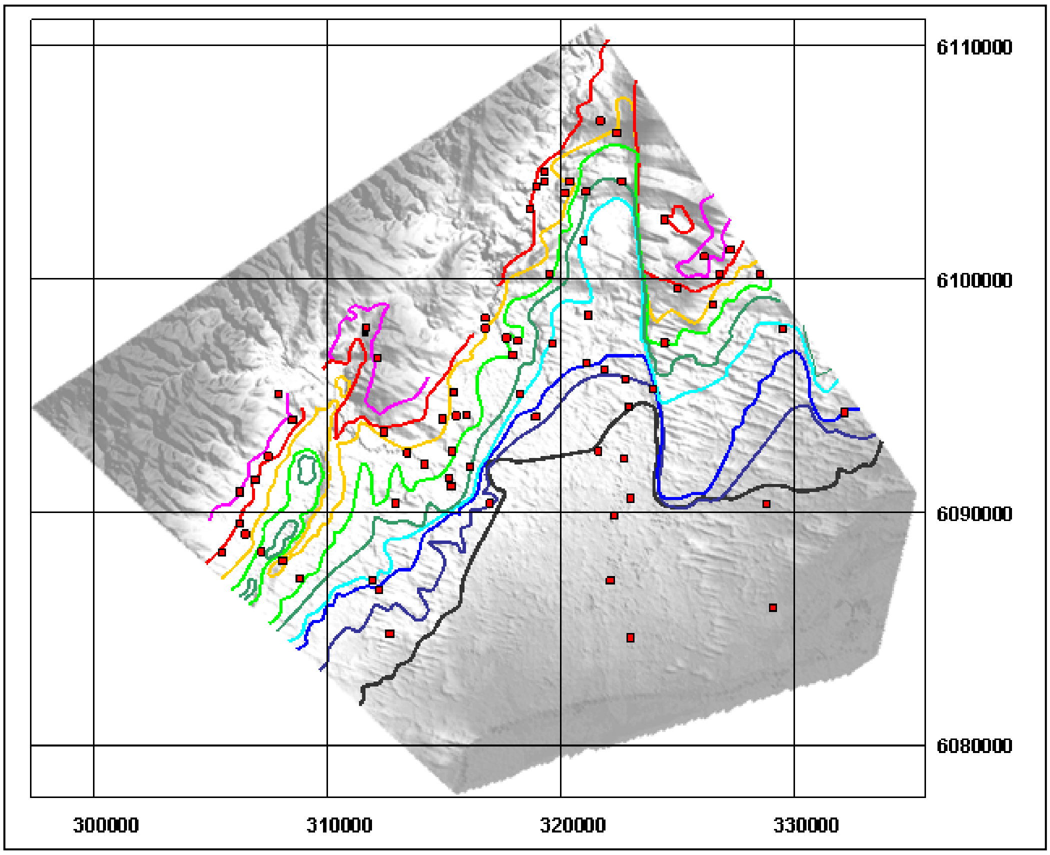


Figure 33. Structure contours on the sediment/basement contact, based on drill hole information (red dots) and AEM data, overlaid on grey DEM. Contours are -100 m (black), -80 m (indigo), -60 m (blue), -40 m (light blue), -20 m (dark green), 0 m (light green), +20 m (gold), +40 m (red) and + 60 m (purple).

6.3 Cross Sections

Seven geological cross sections across the area have been constructed, passing between drill holes with good geological control. The locations are shown in Figure 34, and the sections in Figure 35. The depths to basement between drill holes have not been cross-checked against the structure contours, but it is expected that any discrepancies will be minimal. The sections are designed to show the gross relationships between units. Ground elevations are from topographic profiles generated from the Radar DEM, and boundaries between units are extrapolated between drill holes based on knowledge of the general structure of the area.

The sections show a range of topography and geological structure is present in the area. Some of the relationships contrast markedly from section CM, which is the approximate line of a section that has been published by many authors to illustrate relationships in the local groundwater basin (e.g. Howles 1994), often with extreme vertical exaggeration.

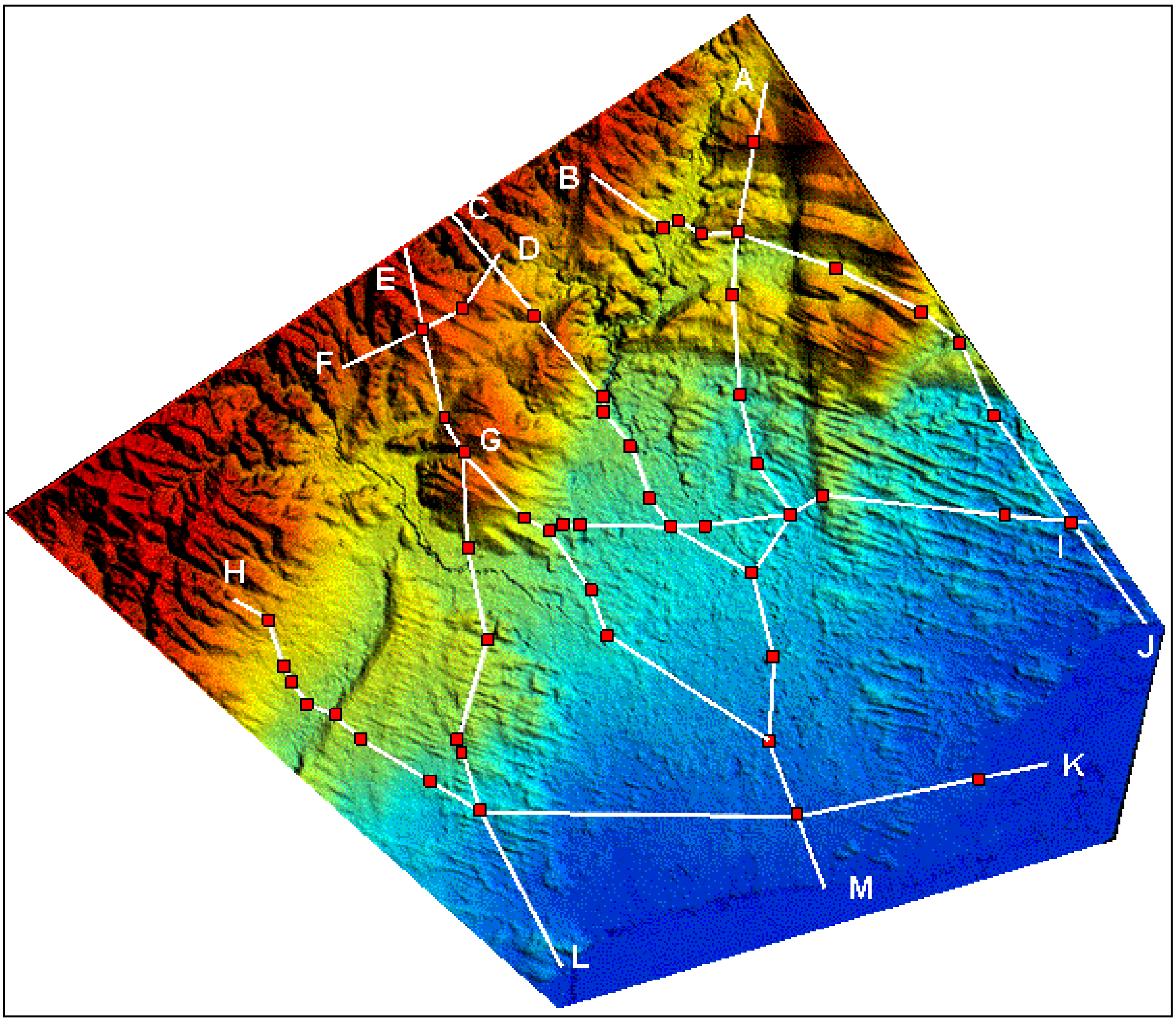


Figure 34. Location of section lines shown in Figure 35 superimposed on the radar DEM. Drill holes providing stratigraphic constraints are shown as red dots.

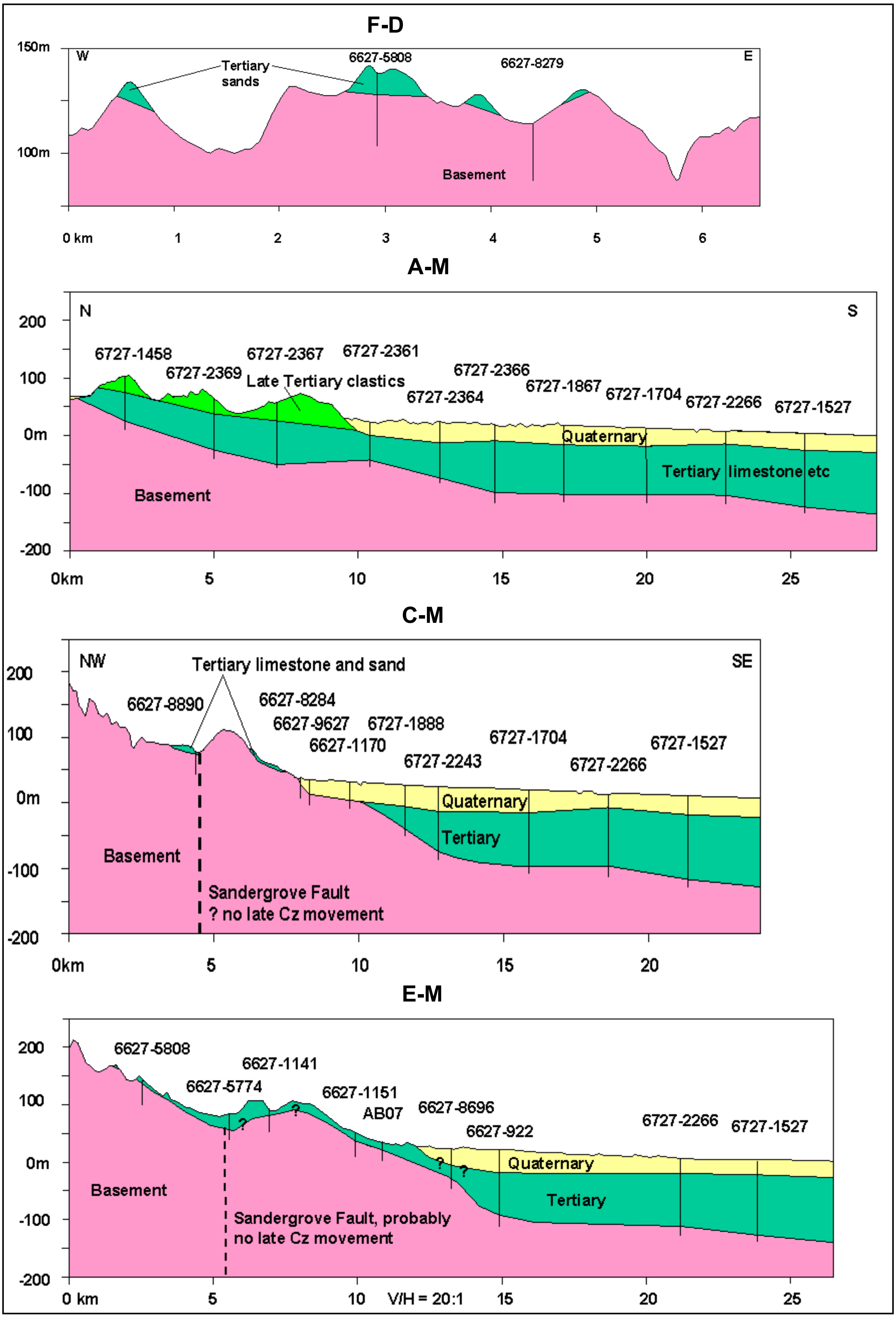


Figure 35. Interpreted geological cross sections along lines shown in Figure 34, based on drill holes, AEM data, and radiometrics (especially section F-D). Topography is from the radar DEM. V/H=20:1

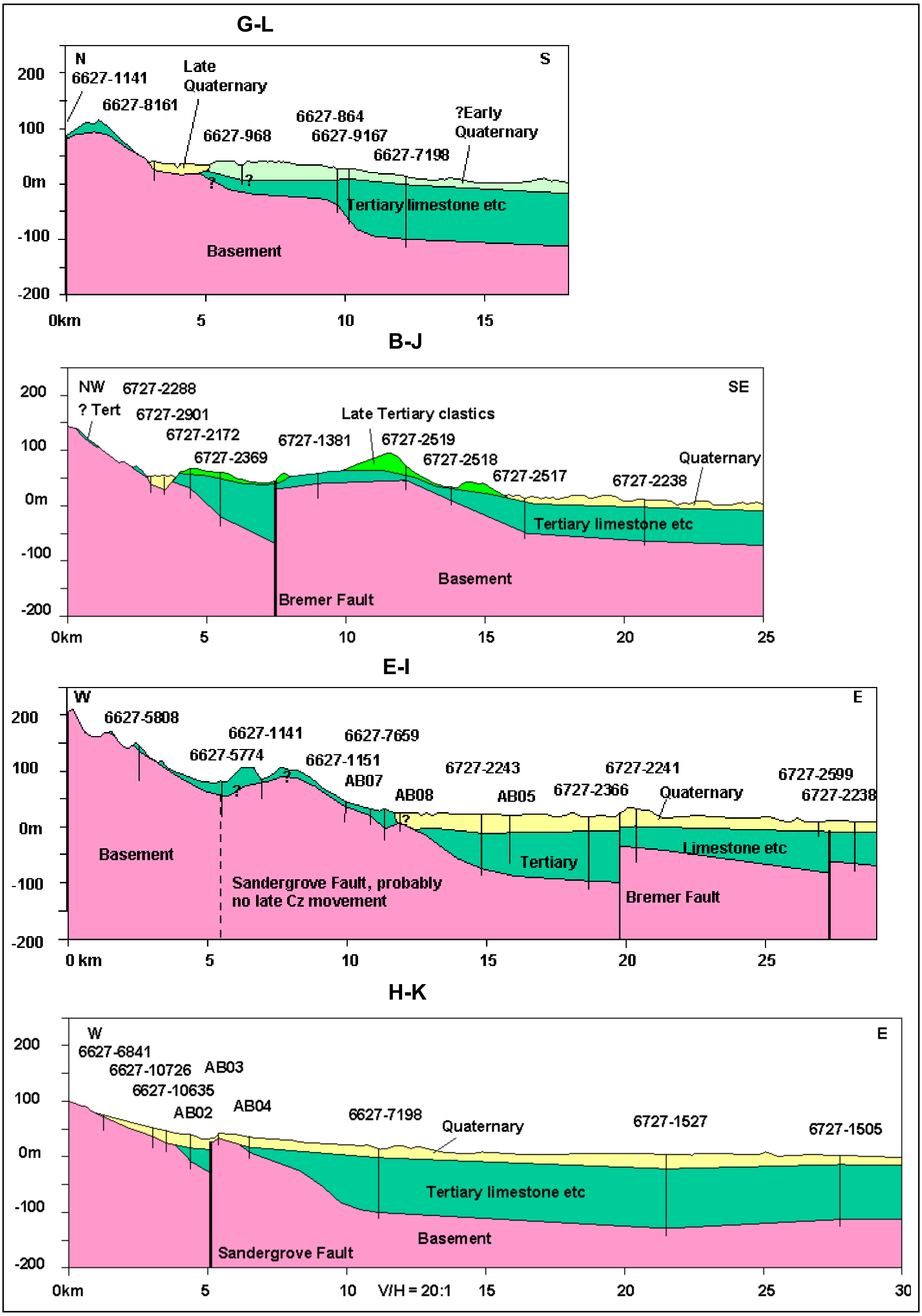


Figure 35 continued

6.4 Quaternary-Tertiary contact

The geometry of the base of the Cenozoic sediments has been described in Section 6.2 above and the top of the sediments is the land surface, as described by the DEMs. However, the geometry of the Quaternary-Tertiary contact has not been modelled as part of this project. It is relatively well known from drill data beneath the Angas-Bremer alluvial plain, e.g. structure contours from contacts in drill holes depicted in figure 3 of Waterhouse & Gerges (1979), and figure 6 of Williams (1978). These show the same gross geometry, but differ in detail, possibly because data on different holes were used to construct the contours. Note that thin Pliocene sediments have been included with the Quaternary aquifer in some holes beneath the alluvial plain and surrounding low elevation areas in interpretations available from the SA geological database. These Pliocene sediments are considered to be part of the upper Quaternary aquifer system rather than the confined Tertiary aquifer. Thus the depths should be taken to be to the base of the upper aquifer system rather than to the base of Quaternary age sediment.

The geometry of the contact away from the alluvial plain area has not been well depicted apart from in cross sections such as figure 3 of Telfer *et al* (2000) (although note that their depiction of depth of basement in this figure is at least partly in error). Available drill data (Appendices 4, 5, 7, 8, 12) suggest that the Quaternary sediments are mostly <20 m thick in the low relief dunefield areas east and west of the alluvial plain. Drill hole data combined with the DEM should allow reasonably accurate modelling of the contact in these areas. However, in the hills east of the Bremer River in the north of the area (see Section 7.6 below), no attempt has been made at depicting the geometry in earlier studies, probably due to lack of information and presence of mostly low quality water in the Tertiary aquifer. Data from mineral sands exploration holes (Appendix 8) and other exploration holes (Appendices 4 and 5) appear to give reasonable control on the depth to the Tertiary limestone aquifer. In the past, lack of good elevation data in this area would have hindered accurate depiction of the contact, but the DEM should allow good control around the drill holes. Errors in the locations of the holes may lead to vertical errors in the location of the contact in areas of steep landform.

The hydrogeological significance of the Quaternary/Tertiary contact in this northern area is not well understood. Detailed lithological logs of mineral exploration holes west of the Bremer Fault (Appendix 5) indicate that a range of sedimentary lithologies including aquicludes overlie Tertiary limestone, i.e. it is likely to form a confined aquifer. However, initial calculations indicate that there may be a window through the overlying lithologies in a low lying area with internal drainage (see Section 7.6). To the east of the Bremer Fault, numerous mineral sands exploration holes (Appendix 8) show that the limestone is overlain by Pliocene sand, which should not form a confining layer. The Pliocene sand in this area could be modelled as part of the unconfined aquifer.

It does not appear from preliminary investigation that the contact between the Quaternary and Tertiary aquifers can be interpreted accurately from the conductivity data. In theory this could only be done where there was either a sharp break in porosity or water salinity at the boundary, although it should be noted that if one aquifer had high porosity and lower salinity water, and the other low porosity and higher salinity water, there still might not be a conductivity contrast across the contact. There are many drill holes across the area in which the location of the contact has been determined (Appendices 4, 5, 7, 8 11 and 12), and it is considered that these data should allow better modelling of geometry than any conductivity data. It should be noted that various structures may affect the geometry of the contact, and these as well as drill hole data should be taken into account when constructing a model.

7. DETAILED DESCRIPTION OF REGOLITH, GEOLOGY AND LANDSCAPE

In this report the area is subdivided into ten spatial units that have relatively uniform landscape, geology and regolith to facilitate their description. These are: Eastern Mount Lofty Ranges, Rises Northeast of Strathalbyn, Sandergrove Plain, Hills East of Strathalbyn, Milang Dunefield, Hills East of the Bremer River, Dunefield East of the Angas-Bremer Alluvial Plain, Lake Alexandrina Marshes, Angas Bremer Alluvial Plain and Lake Alexandrina. These are summarised and discussed separately in Table 2 and the various sections below, and are depicted on Figure 36. The units are somewhat analogous to the land systems of DWLBC (2002), but their boundaries rely mostly on interpretation of deeper earth materials, landform and their origins, whereas land systems also take into account soils and vegetation. The boundaries as depicted in Figure 36 are approximate only. These units are basic natural resource management subdivisions, and may form the basis of any future delineation of smaller management units.

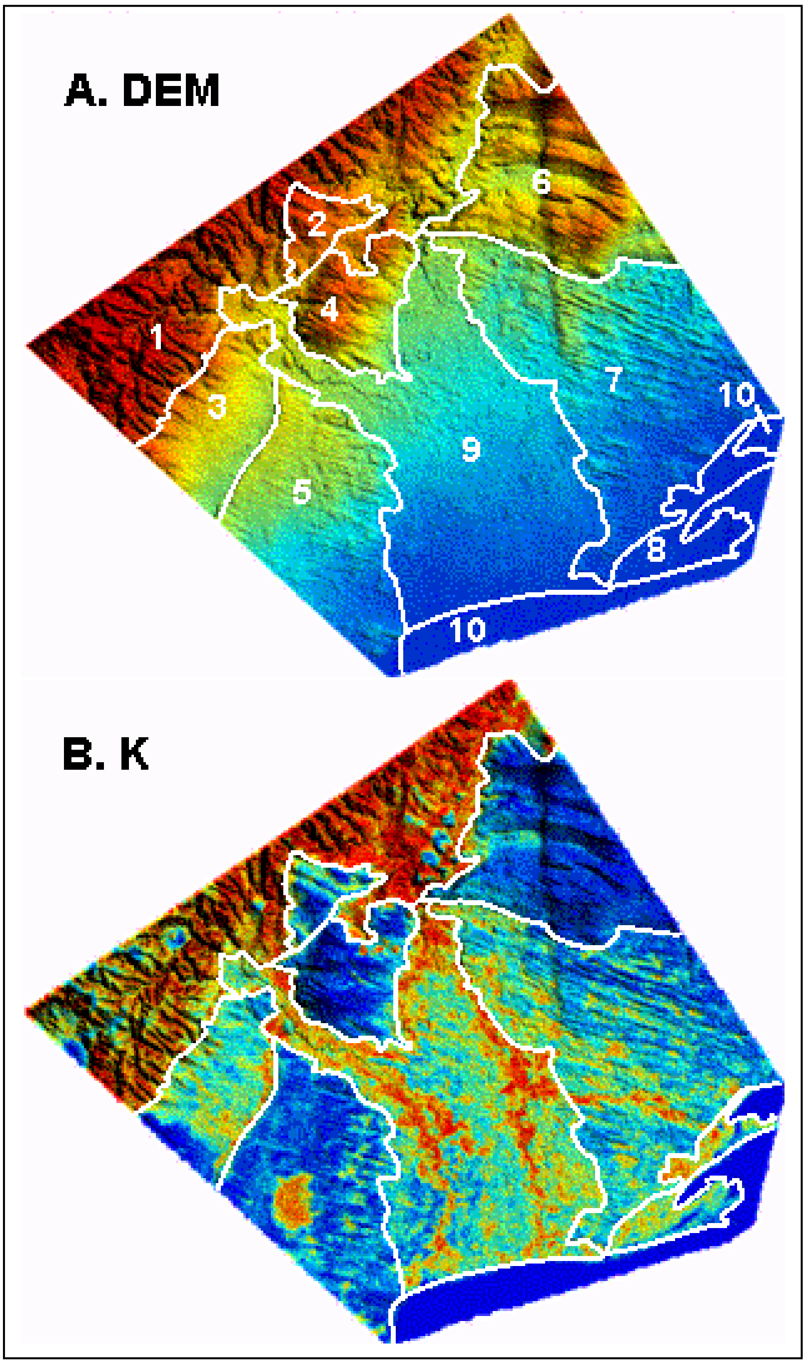


Figure 36. Areas discussed in Section 7, (A) superimposed on the radar DEM with northeast illumination and (B) K channel of radiometrics over greyscale DEM with northeast illumination. 1, Eastern Mount Lofty Ranges. 2, Rises Northeast of Strathalbyn. 3, Sandergrove Plain. 4, Hills East of Strathalbyn. 5, Milang Dunefield. 6, Hills east of the Bremer River. 7, Dunefield east of the Angas-Bremer Alluvial Plain. 8, Lake Alexandrina Marshes. 9, Angas-Bremer Alluvial Plain. 10, Lake Alexandrina.

Unit name	Landform	Earth materials	Hydrogeology
Eastern Mount Lofty Ranges	Erosional hills with local steep slopes. Relatively high geomorphic activity. Well organised drainage.	Slightly weathered to fresh Cambrian metasedimentary basement, Permian sediments in valley in far west, local caps of deeply weathered basement, outliers of Tertiary limestone and sand. Local valley floor alluvium, colluvium on slopes.	Brackish to saline water in fractured rock aquifers. Extensive recharge areas.
Rises northeast of Strathalbyn	Erosional rises, inclined to southeast. Relatively low geomorphic activity, low slopes.	Cambrian bedrock, unknown degree and depth of weathering, discontinuous veneer of Tertiary sand (local ferruginous cement) and limestone, thin valley floor deposits derived from both basement and Tertiary materials. Local calcrete.	Saline water in fractured rock aquifers. Tertiary sediments above water table may store salt and allow rapid deep drainage.
Sandergrove Plain	Coalesced alluvial fans, pediments, erosional rises, alluvial plain of Sandergrove Ck., fault scarp.	Weathered to fresh Cambrian basement, Tertiary limestone and clastic sediments, Quaternary sediments including eroding older deposits and younger alluvial fan deposits. Local calcrete.	Saline to brackish water in fractured bedrock and Tertiary (including limestone) aquifers, possibly confined by near surface muddy sediments.
Hills east of Strathalbyn	Low hills, mostly rounded. Drainage lines mostly absent or poorly organised. Local longitudinal sand dunes.	Weathered to fresh Cambrian basement, eroding veneer of Tertiary limestone and sand, possibly with Quaternary colluvial reworking, local aeolian sand, local calcrete.	Saline to brackish water in fractured bedrock aquifers. Tertiary sediments above water table may store salt and allow rapid deep drainage. May be in hydrological contact with limestone aquifer of the Angas Bremer alluvial plain.
Milang dunefield	Plain gently inclined to southeast with low longitudinal dunes. No organised drainage lines.	Weathered to fresh basement (Cambrian metasediments, and possibly Palaeozoic granite), Tertiary limestone and clastic sediment thickening to southeast, veneer of Early Cenozoic muddy sediment, late Cenozoic aeolian sand, local calcrete.	Saline water in fractured basement and Tertiary (including limestone) aquifers. Limestone aquifer locally above water table. Confined by Quaternary muddy sediment.
Hills east of Bremer River	Low hills, hills (in part Pliocene barrier dunes with superimposed modern longitudinal dunes). Local areas of internal drainage.	Weathered to fresh Cambrian metasediments and local ultramafics, Tertiary limestone and associated clastic sediments, Pliocene dune sand, possible Quaternary alluvial sediments, late Quaternary dune sand, calcrete.	Saline to brackish water in fractured bedrock and Cenozoic sediments (including limestone). Possible local recharge to limestone aquifer from Bremer R and areas of internal drainage. Thick sands may store salt and allow rapid deep drainage

Unit name	Landform	Earth materials	Hydrogeology
Dunefield east of Angas-Bremer alluvial plain	Plain to rises with longitudinal dunes. Local swales with internal drainage. Little organised drainage apart from Mosquito Creek, a flood distributary of the Bremer River.	Weathered to fresh Cambrian basement, Tertiary limestone and associated sediments, Quaternary sediments (alluvial deposits from palaeo Bremer River?), Late Quaternary aeolian sand, calcrete.	Saline to brackish water in Tertiary and Quaternary aquifers, Possible recharge along Mosquito Ck.
Lake Alexandrina Marshes	Marshy plains.	Weathered to fresh Cambrian metasediments at depth, Tertiary limestone and associated sediments, Quaternary alluvial and ?lacustrine deposits, Holocene lake and marsh deposits	Brackish water in Tertiary aquifer, saline water to brine in Quaternary.
Angas-Bremer alluvial plain	Alluvial plain. Incised river channels, terraced land, floodplains, levees, backswamps, source-bordering dunes, longitudinal dunes.	Weathered to fresh Cambrian metasediments at depth, Tertiary limestone and associated sediments, Quaternary alluvial and ?lacustrine deposits, late Quaternary aeolian sand sourced from dunefields to west and local river channels.	Fresh to brackish (locally saline) water in Tertiary aquifer, fresh to saline in Quaternary. Recharge to Quaternary along river channels, possible leakage from Quaternary to Tertiary aquifers.
Lake Alexandrina	Shallow estuary.	Weathered to fresh Cambrian metasediments at depth, Tertiary limestone and associated sediments, Quaternary alluvial and lacustrine deposits, late Quaternary estuarine deposits.	Springs (groundwater discharge zones from Quaternary aquifer) in lake floor. AEM shows areas of high and low conductivity within Tertiary aquifer, probably indicating areas of high and low salinity groundwater.

Table 2. Summary of the ten landscape/earth materials units.

7.1 Eastern Mount Lofty Ranges.

This unit is formed mostly on Cambrian basement rocks, and also areas of Permian sediments in the far west of the area. The Cambrian rocks are typified by incised hilly landscapes with slopes up to 30° and narrow valley floors separated by ridges that have rounded to sharp summits. The Permian sediments in the area occupy broad valley floors. The unit corresponds to parts of the Giles and Woodchester Land Systems of DWLBC (2002). Elevations rise to the west. Radiometric response over the Cambrian rocks is mostly high, reflecting soils derived from the slightly weathered to fresh underlying rocks which are relatively rich in radionuclides, and areas of outcrop. Slight variations in response, indicating variations in soil chemistry, appear locally to correlate with landscape position rather than variations in geology. Thus detailed examination of the radiometric data might prove to be useful for helping to delineate variations in soil properties. This has not been attempted in the current study.

7.1.1 Deeply weathered residuals

Several areas with a blue/green response on ternary radiometric plots (red=K, green=Th, blue=U; Figure 37a), corresponding to low potassium but high thorium and uranium contents (Figures 37b, 38a) are located on ridge crests west of Strathalbyn. These areas have slightly elevated conductivity in the 0-5 and 5-10 m CDI slices (Figure 38b). One of these areas corresponds with the peak of Gemmel Hill (about 303150 6094050), which is characterised by silicified mottled and pallid weathered rock (Maud 1972). A second anomaly 2 km to the southwest (about 301700 6093000) also corresponds with a mapped occurrence of "laterite" (Maud 1972; Horwitz & Thompson 1960). It is most likely that the other anomalous ridge top areas with low potassium preserve a similar weathering profile in basement rocks, although they are not mapped by Horwitz & Thompson (1960). They are outside the area of the maps of Maud (1972). Horwitz & Thompson (1960) also show three small polygons of either "lateritised surface" or "limonite cemented gravels, sands and clays" (it is uncertain which of the two units are depicted, as no letter symbol is applied to the polygons on the map) between about 0.75 and 1.5 km northeast of Gemmel Hill. These polygons lie on a major drainage divide, but do not appear as low potassium anomalies on the radiometric imagery. As depicted on the map, they are ~100 m across, and it is possible that the polygons have been exaggerated for the purposes of map presentation, and are actually too small to significantly affect the radiometric images. These five areas of "laterite" and another area about 800 m SSW of Gemmel Hill (on another local ridge) are also shown as soil polygons with "up to 20% surface ferricrete" and "ironstone soil" (soil unit FeZ) on the Milang 1:50 000 soil sheet (DWLBC 2002).

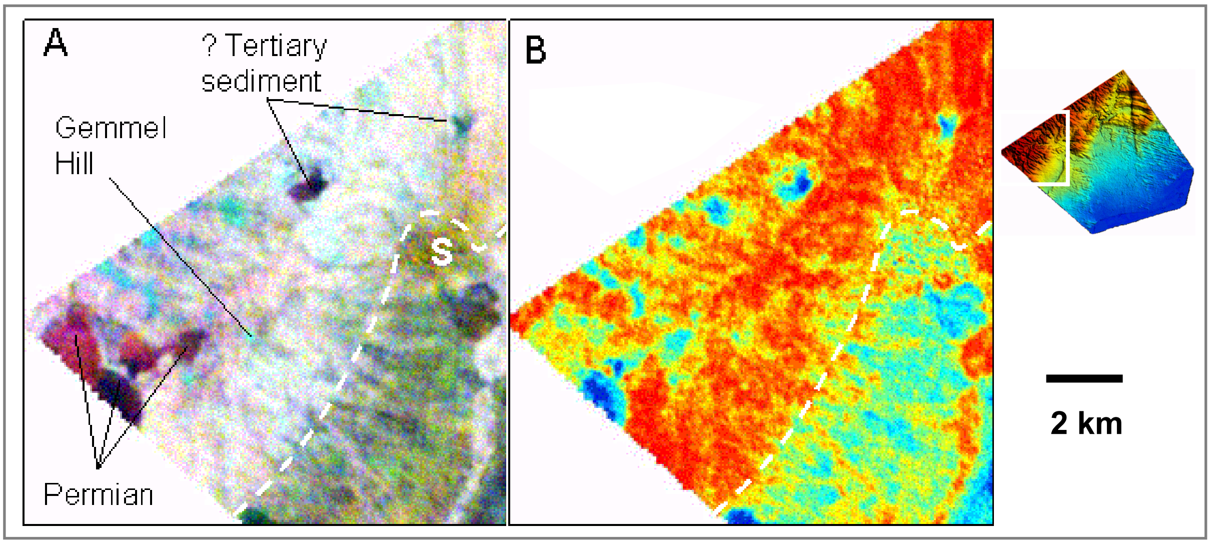


Figure 37. Radiometric images (A, ternary rgb=K Th U. B is K channel) of the Eastern Mt Lofty Range area in the west of the area. White dashed line is approximate edge of basement dominated areas. Some low response areas correspond with areas of Permian rocks or ? Tertiary sediment. Other low response areas such as Gemmel Hill (blue/aqua on ternary image, low K) correspond with deeply weathered bedrock residuals preserved on peaks and ridges. Strathalbyn is indicated by the letter S in 37 A.

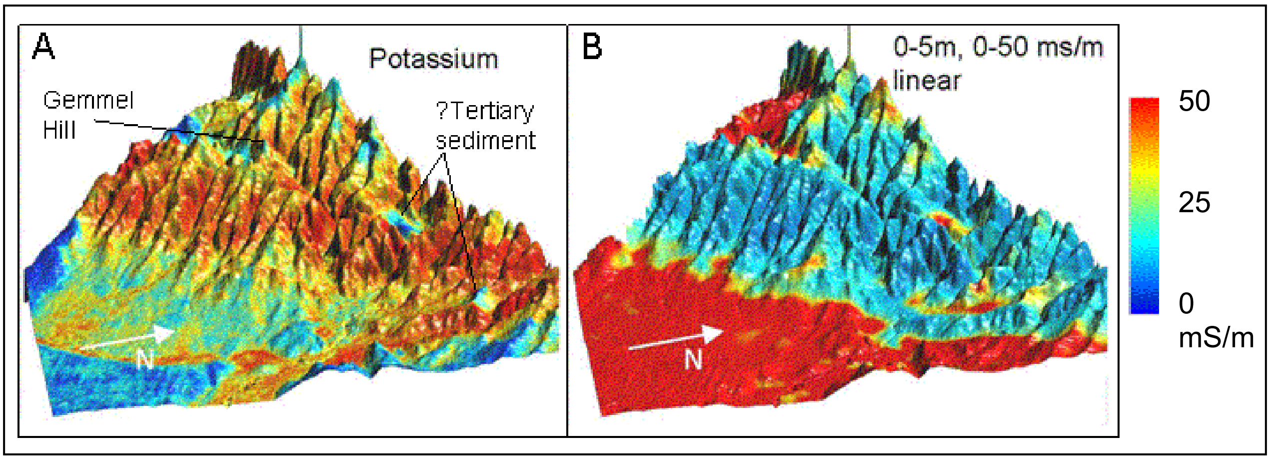


Figure 38. Oblique views of the area of Figure 37 with vertical exaggeration. A. Radar DEM draped with K channel radiometrics. B. Radar DEM draped with 0-5 m depth conductivity, 0-50 mS/m linear colour stretch, showing ridge top location of weathered residuals, areas of ?Tertiary sediments, and Permian rocks in valleys in the west.

7.1.2 Permian sedimentary rocks

Areas of low radiometric response (dull red to black on ternary plots) in the extreme west of the unit (centred around 299000 6094000 and extending east to around 302000 6094000) (Figures 37, 38) correspond to previously mapped Permian deposits (Horwitz & Thompson 1960). They are present in relatively low lying areas which represent a Permian palaeovalley

7.1.3 Other small areas of eroded sediment

A small area (~0.5 km^2) of low radiometric response occurs about 3 km WNW of Strathalbyn at about 305000 E, 6098500 N (more southwestern area labelled as ?Tertiary sediment in Figures 37, 38). Field investigation shows that this is an area of deep sandy soil becoming partly cemented at depth (hand augering was limited to 1.5 m depth by cementation, Figure 39), with fragments of ferruginous sandstone and mudstone locally present at the surface. These indicate that this is an area of sediment rather than basement, either Permian, or more likely (considering the proximity to areas of Tertiary limestone and sediment near Strathalbyn), Tertiary. This area is characterised by a weak AEM anomaly down to around 50 m (Figure 38b). It is an undulating area elevated above the local drainage lines, but lower than the surrounding basement areas.

Figure 39. Area of probable Tertiary sandy sediment west of Strathalbyn, view to east. Location ~ 305080 6098080.

A smaller area of low radiometric response further to the northeast at about 309000 E, 6099600 N (Figures 37, 38) has not been examined in the field, but corresponds in part with a local ridge. It is considered to be most likely a small remnant of Tertiary sediment (most probably sand), with possible areas of colluvial sand reworked down slope to the west by sheetwash from the remnant. Figure 35 section F-D shows a cross section that puts this smaller area in context with other interpreted Tertiary remnants to the northeast, which are discussed in Section 7.2 below.

Small areas of low radiometric response in the north of the unit along the Bremer River correspond to previously mapped outliers of Tertiary limestone and clastic sediments (Johns 1960; Sprigg & Wilson 1954; Thompson & Horwitz 1962; Lindsay & Williams 1977) (Figures 40, 41). Two inclined ridges 1 to 2 km northwest of the outliers (at about 317000 6104000 and 317000 6105200, labelled on Figure 41) also have low radiometric response (greenish hues in Figure 40a, blue to yellow in 40b), and it is interpreted that these areas may be remnants of Tertiary sediment (?sand), most probably with a differing soil type/texture from that of the surrounding basement areas.

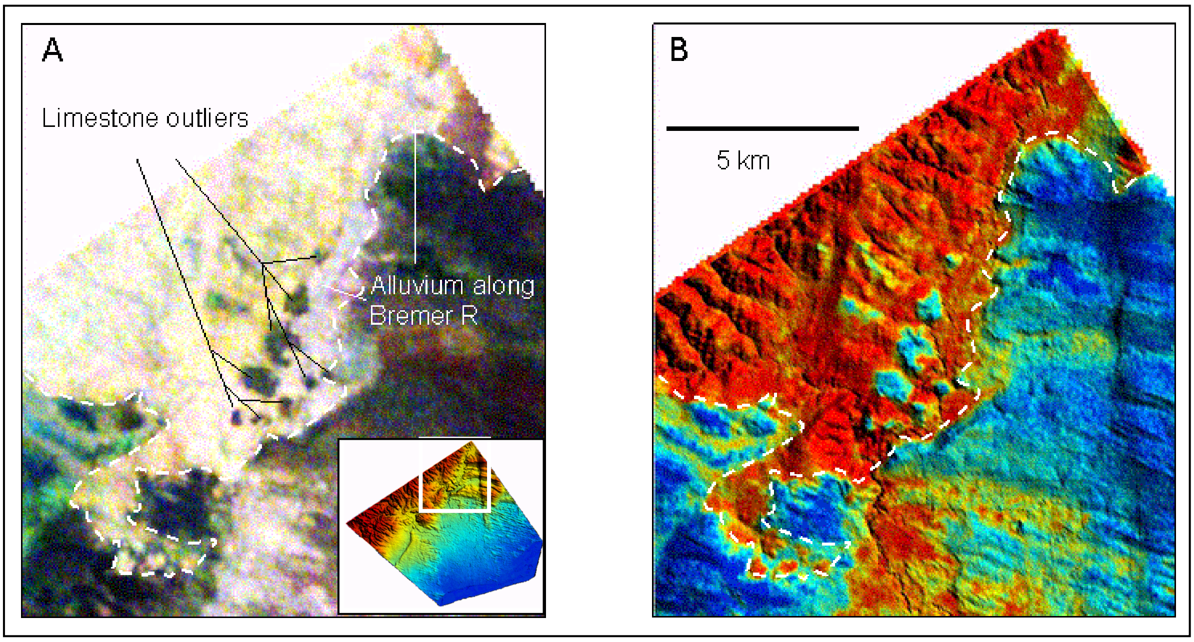


Figure 40. Radiometric images of northern part of the uplands (A, ternary rgb=K, Th, U. B is potassium channel over greyscale DEM with illumination from the northeast). Previously mapped outliers of Tertiary limestone and sediments show as areas of low radioelement response. An area of alluvium along the Bremer River has slightly different colour (more pink) in the ternary image. White dashed line denotes edge of areas of basement outcrop and associated alluvium.

7.1.4 Alluvial deposits

Areas of alluvium along watercourses in the ranges have high radiometric response, reflecting local sourcing from basement rock and minimal leaching/weathering of radioelements in the surface sediment. A relatively large area of alluvium along the Bremer River around project hole AB01 (Appendix 12) is included in this area (Figure 40). This has light pinkish hues compared with the more yellowish hues of basement rocks in Figure 40a. The hole shows that this alluvium is at least 21.3 m thick. However, further downstream before opening onto the main Angas Bremer alluvial plain, the river runs through a bedrock-floored valley at a higher elevation than the base of the alluvium in this drill hole. This implies either very deep scour before deposition of alluvium, or more probably, tectonic influences, with differential movements between the area of bedrock and alluvium along the valley floor. The Bremer River in this area flows approximately along the outcrop of the east-dipping unconformity between basement and Tertiary sediment in the area. As landscape lowering takes place, the surface trace of the unconformity migrates to the east, and it is considered likely that the course of the river has migrated eastwards along with the unconformity.

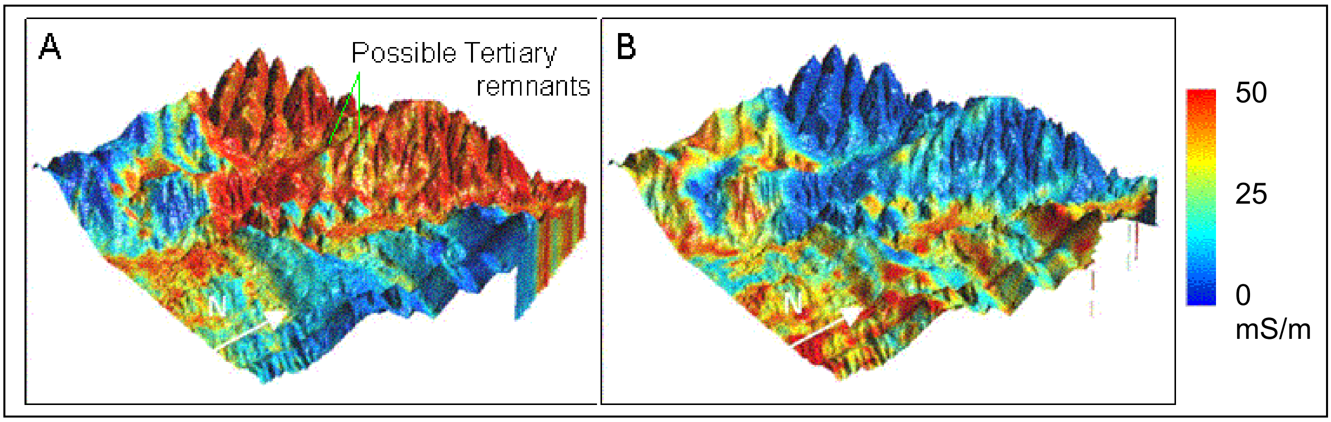


Figure 41. Oblique DEM views of area shown in Figure 40 with vertical exaggeration. A. Potassium channel of radiometrics. B. 0-5m depth CDI, stretched 0-50 mS/m linear to highlight changes in conductivity across the area. Areas of possible Tertiary sediment upslope of the known limestone outliers are suggested by low K content and slightly raised conductivity

7.1.5 Hydrogeology

Groundwater within the unit is expected to be mostly within fractured Cambrian bedrock aquifers. The SA water database shows that salinity of groundwater within the basement areas ranges from 150 to 10 000 mg/l, mostly between 1000 and 5000 mg/l. Permian sediments in the west also contain groundwater. Limited field examination indicates that the Permian sediments are poorly to moderately cemented and include sandstone and conglomerate. Porosity and permeability of the sediments may be locally high, indicating that there may be good aquifers present. The area of Permian sediment within the study area is characterised by moderate AEM conductivity (up to 100 ms/m) at depths up to 100m, indicating probable brackish water. Two water wells are recorded in the SA water database within the area of Permian sediment; these have salinities of 2250 mg/l (6627-6434) and 4810 mg/l (6627-7737). The outliers of Tertiary sediment within this unit should have local good porosity and permeability, but are most probably above the water table. However, these areas may be important for storage of salts above the water table.

The alluvial deposits along the Bremer River around project drill hole AB01 (Appendix 12) are most probably in contact with limestone aquifers to the east. Thus it is probable that river water recharges groundwater in the alluvium, which then helps recharge the limestone aquifer in this area.

7.2 Rises northeast of Strathalbyn

7.2.1 Landform and near surface materials

This unit falls to the southeast, as does the previous unit, but differs in that it is not deeply incised and slopes are much lower. It corresponds to part of the Woodchester Land System of DWLBC (2002). Several shallow southeast-trending valleys with ephemeral drainage lines cross the area. Basement rocks have been previously depicted across most of the unit on geological maps (although the author has not located any outcrop), but local ridge crests have been mapped as undifferentiated Tertiary sediment (Sprigg & Wilson 1954) or Mannum Formation (Thompson & Horwitz 1962). Radiometric response in this unit is mostly subdued, even across most of the areas mapped as basement rocks (Figures 42, 43). The areas mapped as Tertiary sediments have very low response in all three radioelements. Field investigation shows that the ridges are characterised by sandy soils with local lag of fragments of calcrete and ferruginous sandstone (quite distinctly different from basement rock) but no outcropping Tertiary materials were located in this study.

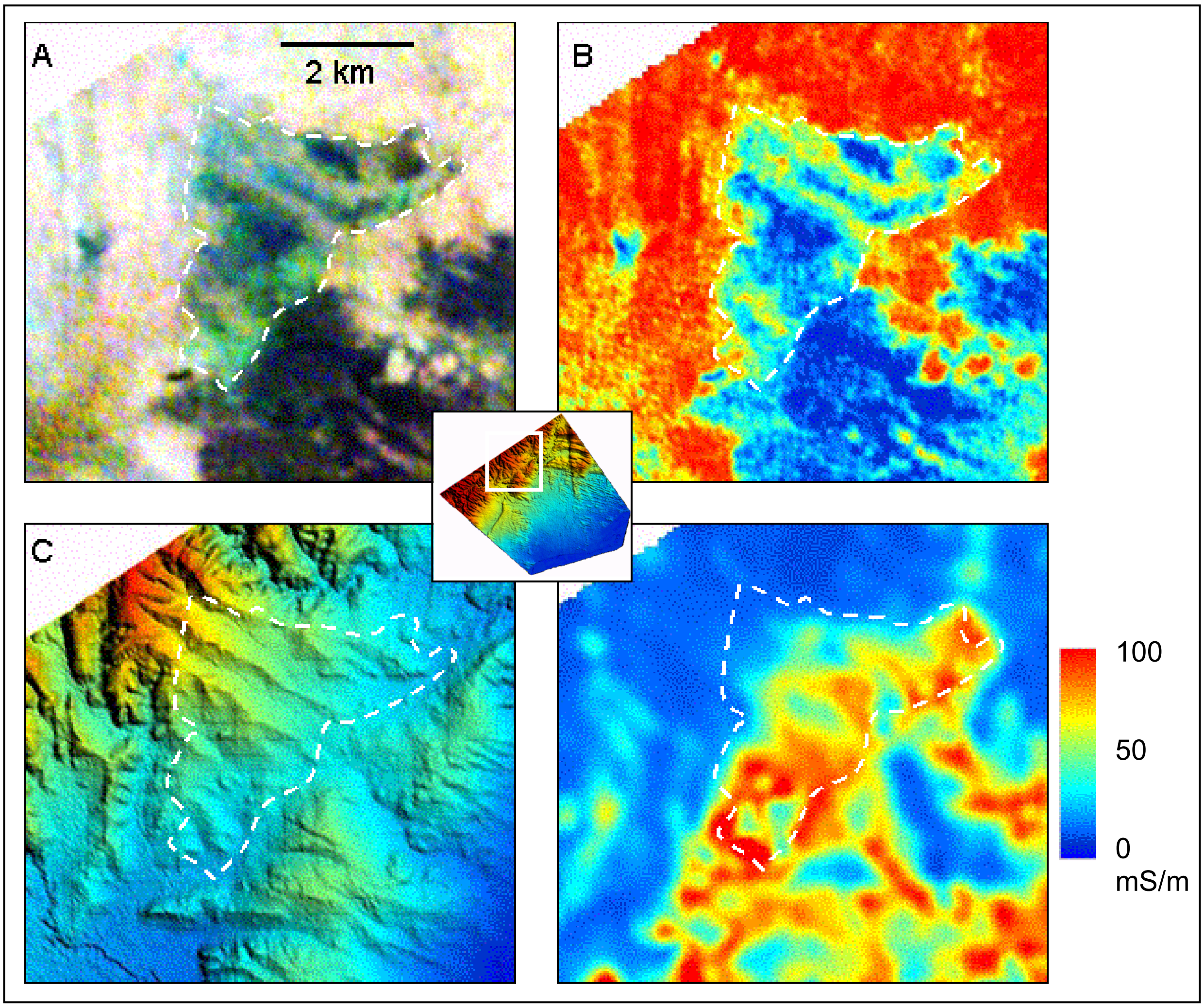


Figure 42. Images of the area of rises northeast of Strathalbyn (outlined by dashed white line). A. Ternary radiometrics rgb =K, Th, U. B. K channel of radiometrics. C. Radar DEM. D. 0-5 m CDI stretched 0-100 mS/m linear. The areas of low radiometric response are interpreted as residuals of Tertiary sandy sediment similar to that which underlies limestone in areas further to the south (eg exposed in quarries and pits east of Strathalbyn). Theses areas are characterised by sandy soil and local lag of fragments of ferruginous sandstone.

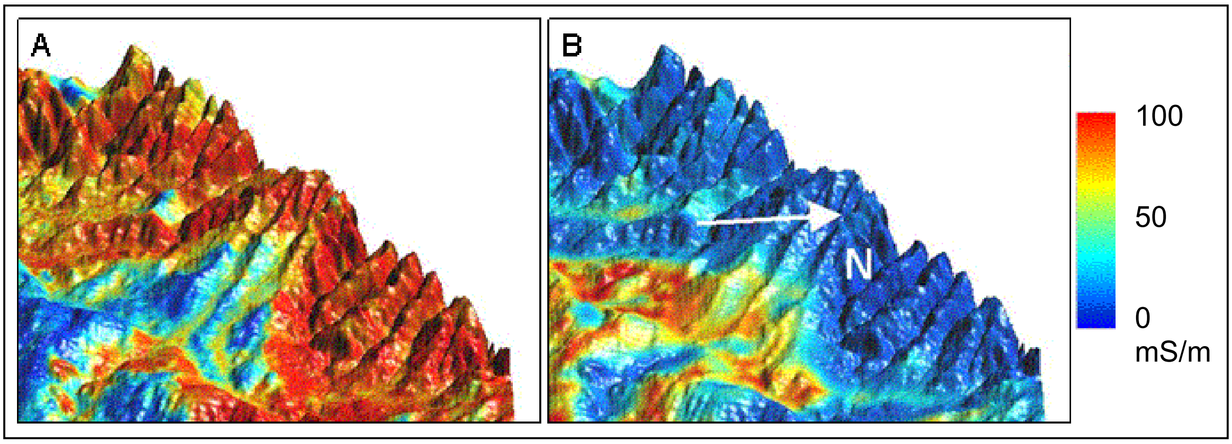


Figure 43. Oblique views of the area shown in Figure 42 with vertical exaggeration. A. Potassium over radar DEM. B. 0-5 m CDI stretched 0-100 ms/m (linear) over radar DEM.

It is interpreted that the sandy soils and lag fragments of iron cemented sandstone are derived from underlying Tertiary sediment similar to mostly uncemented (but locally iron oxide cemented) Tertiary ?estuarine to shallow marine sand and minor gravel (strongly cross bedded, and with sharks' teeth) exposed beneath Tertiary limestone in quarries and pits east of Strathalbyn, a few kilometres from the ridges in this unit (author's observations). Driller's logs (Appendix 7) of water bores in the area (held on microfiche at the Department of Water, Land and Biodiversity Conservation, Adelaide) give some idea of the materials present. Bore 6627-5808 (310978, 6100619) intersected 8.5 m of soil and 'sandy clay' over 1.2 m of 'gravel' over 'brown rock' (basement). Other holes in the central to higher elevation parts of the area intersected a maximum of 3.6 m of material variously described as soil, clay, limestone and sandstone over basement. However, 6627-5774 (311659, 6097668) at the boundary between this unit and the adjoining area of hills to the southeast (see below) intersected sand and gravel to a depth of 26.5 m over basement slate (Appendix 7). Therefore it is probable that there is a discontinuous veneer of in situ Tertiary sediment and material dispersed from this across much of the area, which thickens down slope. This is summarised in Figure 35 sections F-D and E-M.

Several shallow valleys that cross the area have radiometric response higher than for the rest of the area. This is interpreted to be due to presence sediment derived from erosional basement areas upslope rather than residual soil on basement. Bore 6627-8279 (312300, 6101235) drilled in one of the valleys penetrated 3.6 m of 'sandy topsoil' and 'clay' (driller's log, Appendix 7) over basement. The section across the area (Figure 35 section F-D) suggests this is beneath the local level of Tertiary sediment, and that the 3.6 m of sediment is Quaternary valley fill derived mainly from erosional basement areas upslope rather than part of the Tertiary sediment. As a general rule of thumb in this area, it appears that residual to colluvial material developed on Tertiary sediments has lowest radiometric response, material from mixed source has intermediate response, and residual soils and alluvium derived from basement has highest response.

The preservation of Tertiary material in this area and the low relief indicates slow erosion, and suggests that basement rocks in the area may be more weathered than elsewhere due to the rate of weathering front advance possibly being greater than the rate of erosion. AEM data show raised conductivities across the unit, compared with normal basement signatures, even at depths of 50 m. This is interpreted as a being due to higher conductivity in both damp Tertiary material and underlying weathered basement.

The overall general slope of the area to the southeast is around 1-1.5°. This appears to be roughly parallel to the dip on the unconformity surface between the Tertiary and basement. If it is assumed that the unconformity was originally flat lying, this slope represents the amount of tilting in the area since deposition.

The unit is interpreted as having low geomorphic activity, possibly due to low runoff resulting from high water penetration rates into the sands. There may have been some aeolian transport of sand across the area, and some dispersion of surface sediment by sheetwash and alluvial action.

7.2.2 Hydrogeology

Groundwater in the unit is probably entirely within fractured bedrock aquifers, but small amounts could be present within thicker parts of the Tertiary sands, and ephemeral perched water tables could exist over impermeable ferruginous zones within the sands. Nine bores from the main part of the area (6627-5773, -5786, -5789, -5790, -5792, -5808, -6546, -8279, -8890) have TDS ranging from ~ 4000 to 18 000 (average ~ 10 000) mg/l (from the SA water bore database). Four bores from the high elevation apex area have TDS from ~2000 to 7000 (average 4000) mg/l. Bores in the surrounding high relief areas mostly have TDS around 1000 to 4000 mg/l. Thus this unit appears to have significantly saltier groundwater than the surrounding higher relief areas of basement outcrop, probably relating to salt storage in the thicker regolith profile present, although the high elevation area at the apex of the unit has better quality water, probably due to the proximity to adjacent recharge areas.

7.3 Sandergrove Plain

7.3.1 General landforms and Cenozoic materials

This unit is characterised by low slopes to the southeast, with slightly higher elevation areas in the extreme south and north. It is approximately equivalent to the Sandergrove and part of the Woodchester Land Systems of DWLBC (2002). It is bounded to the west by hills of the eastern Mt Lofty Ranges, to the north by the alluvial plain of the Angas River, and to the east by the relatively steep ~15 m high west-facing scarp of the Sandergrove Fault. Several creeks emanating from the ranges to the northwest cross the unit; some have eroded deep gullies that expose near-surface regolith materials. These flow to Sandergrove Creek, which runs along a fault angle depression at the foot of the fault scarp.

The interpreted geomorphology and regolith geology of the area as outlined below and depicted in Figure 44 is from the author's field observations, information in Maud (1972) and DWLBC (2002), and interpretation of the DEM, AEM, radiometrics (including 3D views of radiometrics draped over the radar DEM, Figure 45), drill data (project drill hole AB02 and drillers logs of water bores held at the Department of Water, Land and Biodiversity Conservation in Adelaide) and the Milang One Mile geological sheet (Horwitz & Thompson 1960). The K content best shows the variations in radiometric response (the three radioelement responses are approximately proportional). The unit can be subdivided into six geomorphic/regolith subdivisions (Figure 44) that are described below.

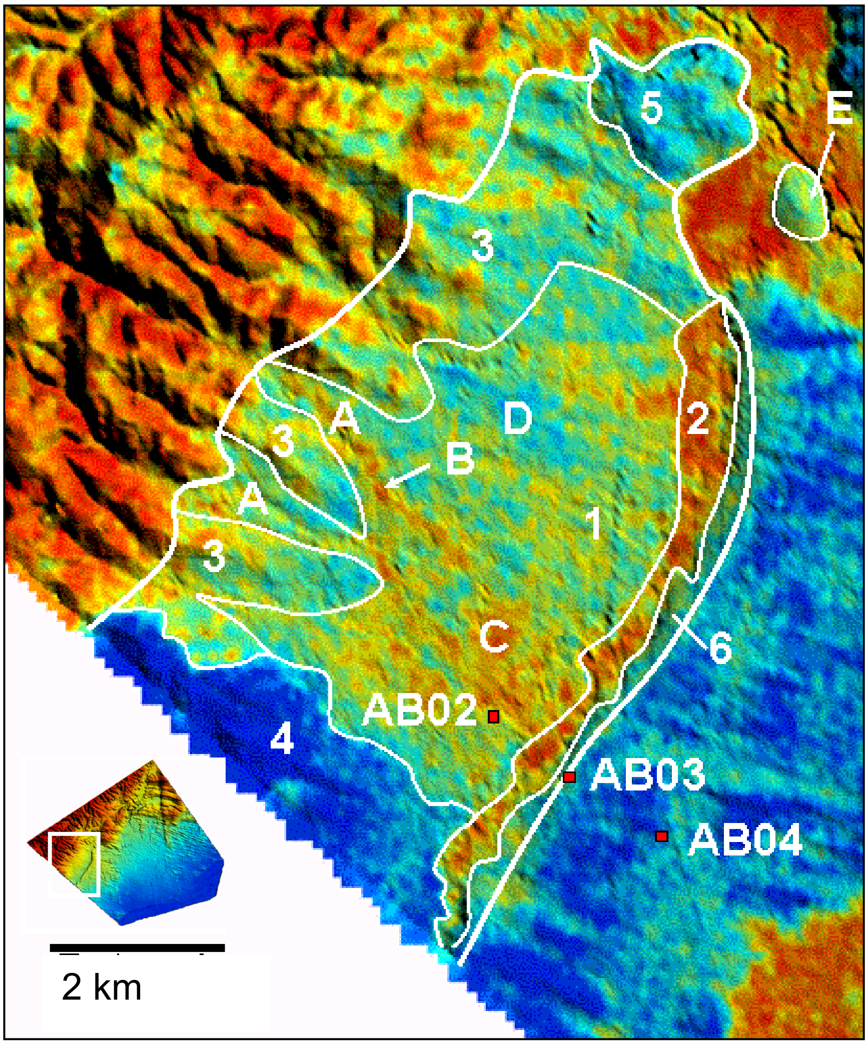
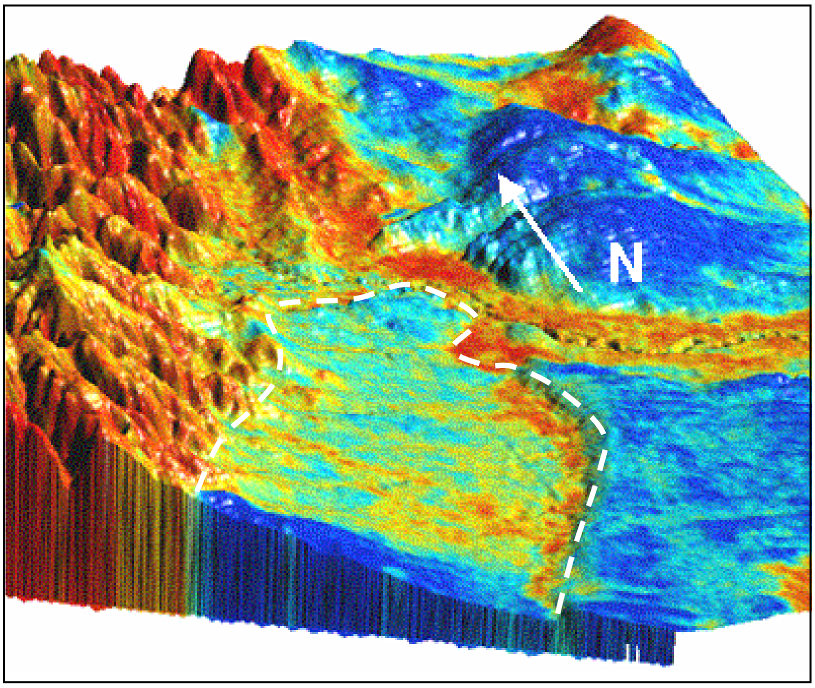


Figure 44. Potassium radiometric image of Sandergrove plain, over greyscale DEM with illumination from the northeast, annotated to show 1: coalesced alluvial fans. 2: alluvial plain of Sandergrove Creek. 3: rises and pediments over basement and possibly Cainozoic sediments. 4: broad rise, underlain by ?Cenozoic sediment. 5: rises of Miocene limestone and poorly cemented sandstone. 6: west-facing fault scarp up to 15 m high. A: constrained proximal fans. B: narrow zones with high K response corresponding to levees; also ?early Quaternary sediment exposed in gully. C: broad areas of high K response probably corresponding to floodout deposits. D: area of low K response corresponding with sandy soils, probably a sandy part of the fan system. E: rise of Tertiary limestone and sediment over basement.



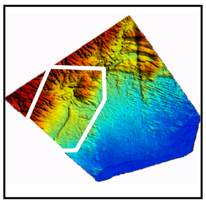


Figure 45. Oblique view of the Potassium channel of radiometrics draped over the radar DEM, showing the Sandergrove plain (within white dashed line) in relation to the surrounding landforms.

Quaternary alluvial sediments cover much of the area, deposited in the broad low angle fans and in the alluvial plain along Sandergrove Creek. Older Quaternary and Tertiary clastic and calcareous sediments are buried below the alluvial sediment and are probably also present immediately beneath soil cover in pediments further upslope. Basement rocks subcrop beneath soil cover in low erosional landforms and pediments. Horwitz & Thompson (1960) mapped a broad southeast-trending ridge in the extreme southwest partly as Permian sediments and partly as surficial units. The extremely low radiometric response of the ridge within the study area suggests that this interpretation may be correct. However, the author considers this area is more likely made up of eroded ?early Quaternary sediments over Cambrian basement, as outlined below.

7.3.2 Alluvial Fans

The fans (unit 1 on Figure 44, Figure 46) have a slightly undulating surface inclined to the southeast at about 0.7°. They are crossed by ephemeral watercourses, some of which have eroded deep gullies (Figure 47). Upstream, the fans become confined between low pediments, and could be better described as alluviated shallow valleys (as at A in Figure 44; Figure 48). Alluvium of the fans exposed in the gullies is mostly red/brown fine silty sand to sandy silt with some horizons of pebbles to boulders in a fine matrix (Figure 49). There is local development of powdery and harder rhizomorphic carbonate (Figure 50), and pedal soil textures are mostly present. The topmost layer in some areas is structureless (apedal) greyish silt that forms levees up to ~60 cm high beside the gullies, which correspond with elongate areas of high potassium response (Figure 44 location B, Figures 47, 50). The high response is probably due to high muscovite content in the silt, sourced from erosion of micaceous basement rocks. It is probable that the gullies have deepened and widened since clearing of the area, partially eroding the levee sediment and leaving it exposed in the gully walls. The gullies become shallower downstream, and there are larger areas with high K response (as at location C in Figure 44). These areas have not been studied in the field, but the DEM suggests they are probably floodout areas where channels become poorly defined and sediment has been deposited over broad areas by sheet flow during high rainfall events. Much of the fan surface has an intermediate to low response, probably due to presence of quartz-rich sandy topsoils formed either by eluviation of fines or accumulation of thin sheets of aeolian sandy material. Part of the fan surface has a very low radiometric response (location D in Figure 44), slightly higher elevation than the surrounding areas, and very sandy surface soils. The driller's log of the nearby drill hole 6627-1013 (Appendix 7) suggests that fine sediment is present to a depth of about 16 m. Therefore it is likely that the sand is a near-surface feature rather than part of a thick accumulation. On the ground the area appears to possibly be a low dune, but its irregular plan shape suggests it is more likely a sandier part of the fan that is now slightly upstanding due to the inability of the sand to be compacted.

Figure 46. View to northwest over alluvial fan surface (foreground) and pediments (middle distance) to hills of the eastern Mt Lofty Ranges. Taken from ~ 306400, 6090000

Figure 47. Exposure of partly cemented bleached to mottled sandstone beneath red/brown alluvium in an eroded gully draining to Sandergrove Creek, view to northwest. Note gentle slopes away from gully, indicating presence of levee deposits. Location ~ 306212 6090689

Figure 48. Upstream part of the gully in Figure 47, with ~ 3 m of alluvium overlying basement outcrop (circled), looking northwest. Eastern margin of the Mt Lofty Ranges in the background. Location ~ 305628 6091386.

Figure 49. Red brown alluvium (silty sand with pebble beds) exposed in a gully draining to Sandergrove Creek, overlying partly cemented sandstone (? Early Quaternary). Location ~ 306212 6090689. Exposure is ~ 4 m high.

Figure 50. Silty alluvium exposed in banks of a gully draining to Sandergrove Creek. Note structureless grey upper horizon (young levee deposits) and development of powdery regolith carbonate (light coloured texture). Location ~ 306426 6090614.

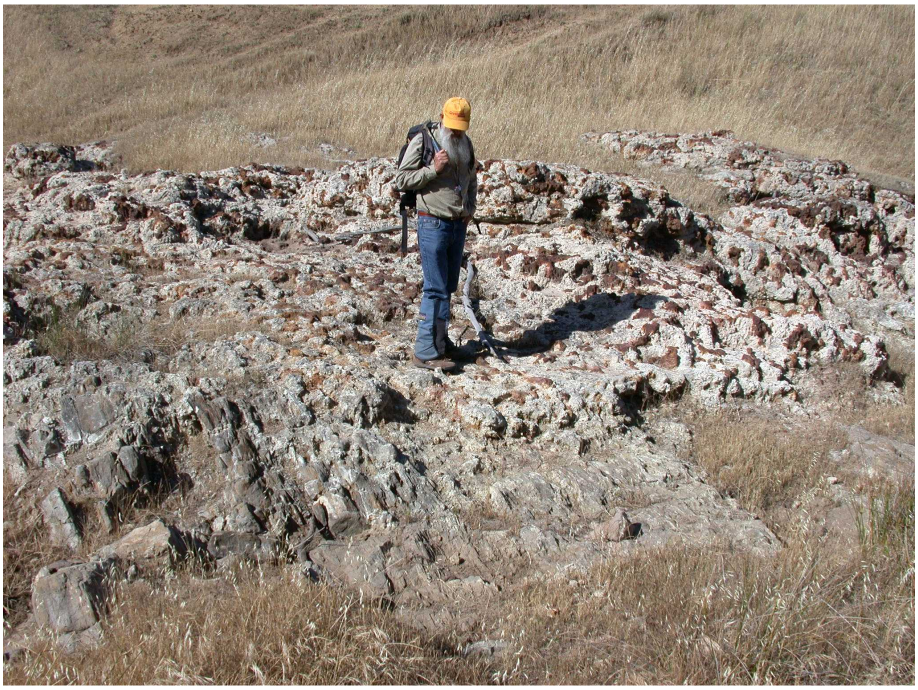


Figure 51. Mottled sandstone overlying steeply dipping basement (lower left) in an eroded gully draining to Sandergrove Creek. Location ~ 306132 6090740

The alluvium overlies basement rocks in the upper parts of the fans (Figure 48). However, further downstream older sediment that disconformably underlies the alluvium and thickens to the southeast is locally exposed. Horwitz & Thompson (1960) and Thompson & Horwitz (1962) mapped two polygons of this material as undifferentiated Tertiary sediment. The author has located one of these in a deep gully at 306212 E, 6090689 N and upstream for about 300 m where the sediment pinches out between alluvium and basement (Location B in Figure 44, Figures 47, 49 , 51 and 52). Partly cemented medium grained quartz sandstone with local granules and pebbles is the dominant lithology.

The sand grains include many well-rounded and polished grains, similar to those present in outcropping Miocene limestone and clastic sediment around Strathalbyn. The grains are set in a white clayey to reddish ferruginous matrix. The granules and pebbles are angular to rounded, and are mostly quartz, with some other resistant lithic clasts, and rare clasts of less resistant mica schist. Many of the exposures are mottled, but bleached rock locally predominates. Some of the mottles are well cemented with iron oxides. Traces of bedding are mostly absent, although there is an exposure of thick bedded very fine sandstone at the downstream end of the outcrops. The author also investigated the other map polygon of 'Tertiary sediment' (also corresponding to an incised gully), but no exposures of sedimentary material other than red/brown alluvium were observed.

Figure 52. Mottled sandstone with rounded pebbles and rounded to angular quartz granules. Location ~ 306000 6090800.

Project drill hole AB02 (Figure 44, Appendix 12) intersected 47 m of sediment (25 m of patchily cemented silty to sandy clastic sediment over 22 m of Tertiary limestone and clay) over basement (Jones *et al*. 2003). The limestone sequence consists of calcarenite with scattered quartz grains, and calcareous green to yellow clay with shell fragments. Small ferruginous grains and pebbles of bedrock are present at the base of the sediment. At least this part of the section is Tertiary, similar to material exposed around Strathalbyn and further north (eg Lindsay & Williams 1977). Overlying this is 6 m of muddy (12-30% silt and clay) fine to medium sand. Over this is 15 m of sediment that is a sand/mud mixture (mostly 30-50% sand, 30-50% silt and 15-20% clay) that is in part cemented (enough to induce drill pipe chatter on the large capacity mineral exploration aircore drill rig used). The sand content of this interval generally decreases upwards. The top 4 m is sandy mud (around 20% sand, 60% silt and 20% clay).

The age of the mottled sediment exposed in the gully, and the sediment immediately above the limestone in AB02 is not known. The material in the gully exposure could either be Miocene, part of the marine to estuarine carbonate-dominated sequence deposited in the Murray Basin prior to the mid-Miocene depositional hiatus, or younger, possibly part of the terrestrial Currency Creek Formation of Maud (1972), defined from an area about 8 km to the southwest of the study area. The Currency Creek Formation is interpreted by Maud to be old Quaternary outwash sediment that is now being deeply incised by rivers and thus relates to a depositional system not related to modern landscape. The author examined exposures of this unit about 7 km southwest of the study area (at 302830 E, 6081646 N), and found that here it consists of red/brown silty fine sand with scattered pebbles and some pebble bands, quite different in appearance to the mottled gully exposures. The presence of well-rounded quartz grains in the gully sediment suggests it might be part of the Miocene sequence, but this is not diagnostic.

The division and possible age of the clastic sediment in AB02 is problematic. The top of the carbonate dominated sequence at 25 m depth may be a disconformity, with Currency Creek equivalent sediment above, or the basal 6 m of sandy clastic sediment could be part of the Miocene carbonate-dominated sequence. The overlying 19 m of muddier sediment has cemented intervals below 12 m, implying greater age, but the surface sediment is Holocene, being part of the modern fan-deposited sequence. There are no obvious contacts in the sequence, and none of the clastic sediment is suitable for dating by palynology due to weathering, so at this stage no divisions or correlations are attempted.

The description of the Sandergrove Land System of DWLBC (2002) states that the area is underlain by the Blanchetown Clay (for example, a soil pit in the depositional plain part of the unit at 306650 E 6091150 N exposed sandy loam over calcareous red clay). The author does not support the use of this stratigraphic interpretation, as the clay material has a different origin and most probably different age from the Blanchetown Clay at its type section on the Murray River 5 km south of Blanchetown (Brown & Stephenson 1991; Firman 1973).

Driller's logs of water bores in the unit and its extension to the southwest (held at the Department of Water, Land and Biodiversity Conservation in Adelaide) record sediment thickness up to 48 m, including limestone (eg 'coral limestone' from 24 to 32 m in 6627-6979) in several holes (Appendix 7). The driller's log of one hole, 6627-7089 (309176 E 6090163 N), records that the hole bottomed in sediment (clay, sand. sandstone and mudstone) at 91 m, but the author considers this is unlikely given the AEM data for the hole locality. It is likely that the depths for this hole have been recorded in feet, not metres, and depths are shown as such in Appendix 7 (i.e. 28 m). AEM data suggest conductive material at depths of up to ~60 m across the area, and the thickness of sediment from drillers logs has been combined with AEM data to give interpreted approximate isopachs of sediment in Figure 53.

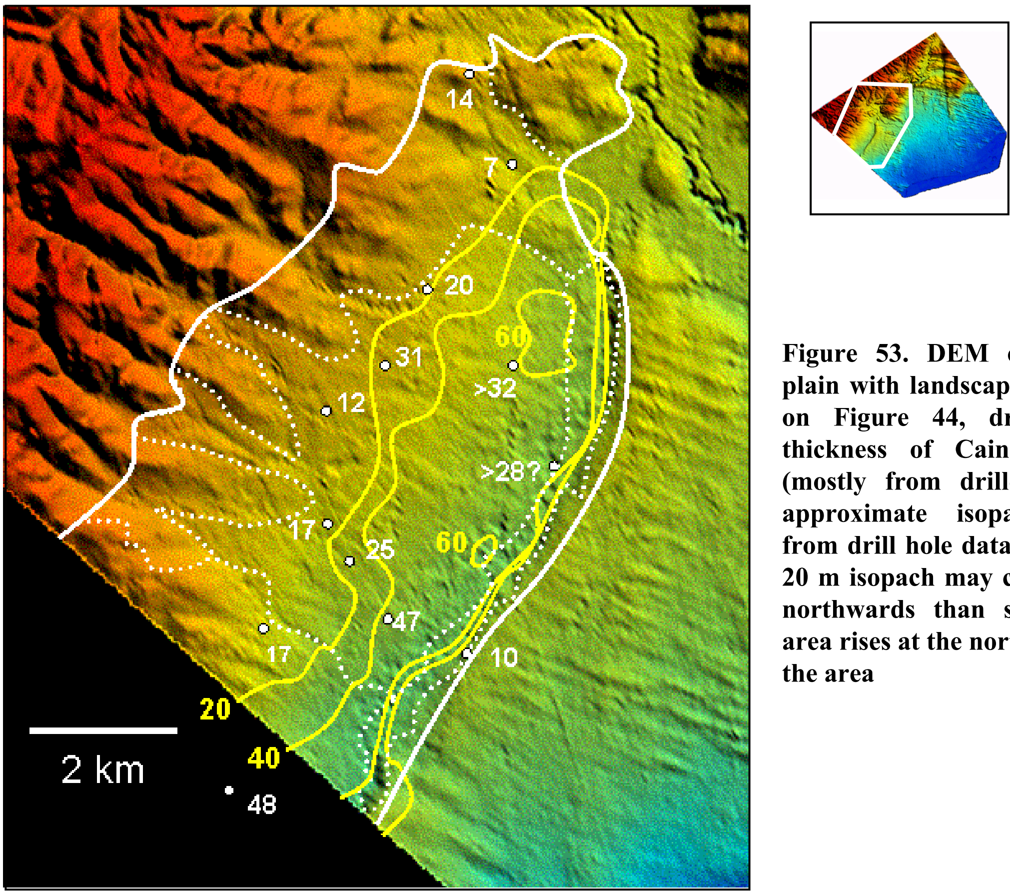


Figure 53. DEM of Sandergrove plain with landscape boundaries as on Figure 44, drill holes with thickness of Cainozoic sediment (mostly from driller's logs), and approximate isopachs estimated from drill hole data and CDIs. The 20 m isopach may continue further northwards than shown into the area rises at the northeastern end of the area

7.3.3 *Sandergrove Creek alluvial plain*

A zone of high radiometric response along Sandergrove Creek, continuous with the main Angas River alluvial plain near Strathalbyn corresponds to a narrow alluvial plain (Figure 44, area 2). Airphoto interpretation and the DEM indicate that Sandergrove Creek is the course of a former flood distributary or possibly even former main channel of the Angas River. Thus at least some of the alluvial sediment has been sourced from the Angas River as well as the local stream catchment. The area immediately around the modern channel is locally characterised by terraces and abandoned meander loops (clearly visible on airphotos) which appear to relate to much higher stream flow than the modern limited catchment of the creek suggest would be possible. Thus the author agrees with Maud (1972) that it is a classic underfit stream.

7.3.4 *Pediments and low relief erosional landforms*

Pediments and low relief erosional landforms over Cambrian bedrock, Tertiary marine sediments and possibly ?early Quaternary sediment (Figure 44, area 3) are present to the west of the fans, and in a broader area in the north. There is a subtle break of slope where the pediments abut the low angle alluvial fans. Where radiometric response is locally high, soils are most probably derived from underlying bedrock. Elsewhere where response is lower, older Quaternary or Tertiary sediment that is now being eroded is most probably present. For example the area around drill hole 6627-7235 in the north of the area has low response. The driller's log of this hole records brown clay with small amounts of limestone to 7.3 m depth, over grey schist (Appendix 7). The proximity of this drill hole to an area of known Tertiary sediment (it is the second most northern drill hole in Figure 53, close to rises known to be underlain by Tertiary sediment (area 5, Figure 44) indicates that the clay sediment is most likely Tertiary age.

Locally, areas of low K radiometric signature continues upslope into more dissected areas to the west, to elevations of up to 120 m (eg at about 305300 E 6092350 N, and 306300 E 6093700 N). These areas have not been investigated in the field, but may represent small areas of tilted Tertiary sediment preserved on slopes adjacent to the main area of preserved sediments.

7.3.5 *Broad ridge in the south*

A broad ridge in the south of the area has low radiometric response and sandy soils (Figure 44, area 4). It is the northern part of a large area of sandy soils that extends to the southeast over probable early Quaternary Currency Creek Formation (Maud 1972). Drill hole 6627-8654 (305563 E, 6088152 N) within this unit intersected 17.3 m of mudstone and sandstone (driller's log, Appendix 7). The Milang one mile geological sheet of the area (Horwitz & Thompson 1960) indicates that Permian sediments may be present. Given the presence of Tertiary and younger sediment in the nearby project drill hole AB02 (Figure 44), it is considered that the ridge is more likely to be made up of Cenozoic than Permian sediments. The 3D geometry of the area of low radiometric response indicates that the sediments thin to the west, with basement present beneath soil on the more westerly part of the northern flank of the ridge. Calcrete is locally exposed on the northern margin of the ridge, for example at shallow scrapes at 305521 6088339. This further suggests that Tertiary rather than Permian sediments are present.

7.3.6 *Rise of Miocene sediment in the north*

This area (area 5, Figure 44) rises about 15 m from the Angas River floodplain, and is underlain by Miocene limestone and clastic sediment. Calcarenite with numerous rounded quartz sand grains and green clay with sand-sized rounded ferruginous clasts was observed by the author at a building site (308547, 6095125) near the crest of the rise in late 2002; this exposure has since been covered by soil, but loose boulders of limestone have been retained for landscaping. A road cutting near 309310, 6088339 has exposed poorly sorted sand and granule gravel with crude bedding and many rounded quartz grains. This is probably an exposure described by Horwitz (1960) as being strongly cross-bedded, with shark's teeth present in the sands. Much of the surface of the rise has a well-developed calcrete cap. The thickness of sediment may exceed 20 m over parts of this area due to relatively high elevation of the land surface, but no attempt has been made to show this in Figure 53 due to lack of data. A nearby rounded rise surrounded by Angas River alluvial plain (feature E on Figure 44) has calcrete-bearing soils and is probably also underlain by Tertiary sediment, but there appear to be no exposures to confirm this.

7.3.7 Sandergrove Fault scarp
The eastern boundary of this unit is a 10-15 m high west-facing slope (mostly <6°, estimated from the radar DEM) several hundred metres wide with a curvilinear plan shape (area 6, Figure 44; Figure 45). Project drill hole AB03 near the top of the slope intersected basement at 10m depth (RL of contact ~ +33 m, Appendix 9), whereas AB02 (one km to the northwest) intersected basement at 47 m (RL ~-7 m) and AB04 (one km to the southeast) intersected basement at RL ~+8 m, showing that the west-facing slope corresponds with a basement high. The landforms and basement geometry around this slope indicate that it results from relatively recent fault movement (east side up) along the Sandergrove Fault (see Section 6.1.3), with Sandergrove Creek flowing along the fault angle depression.

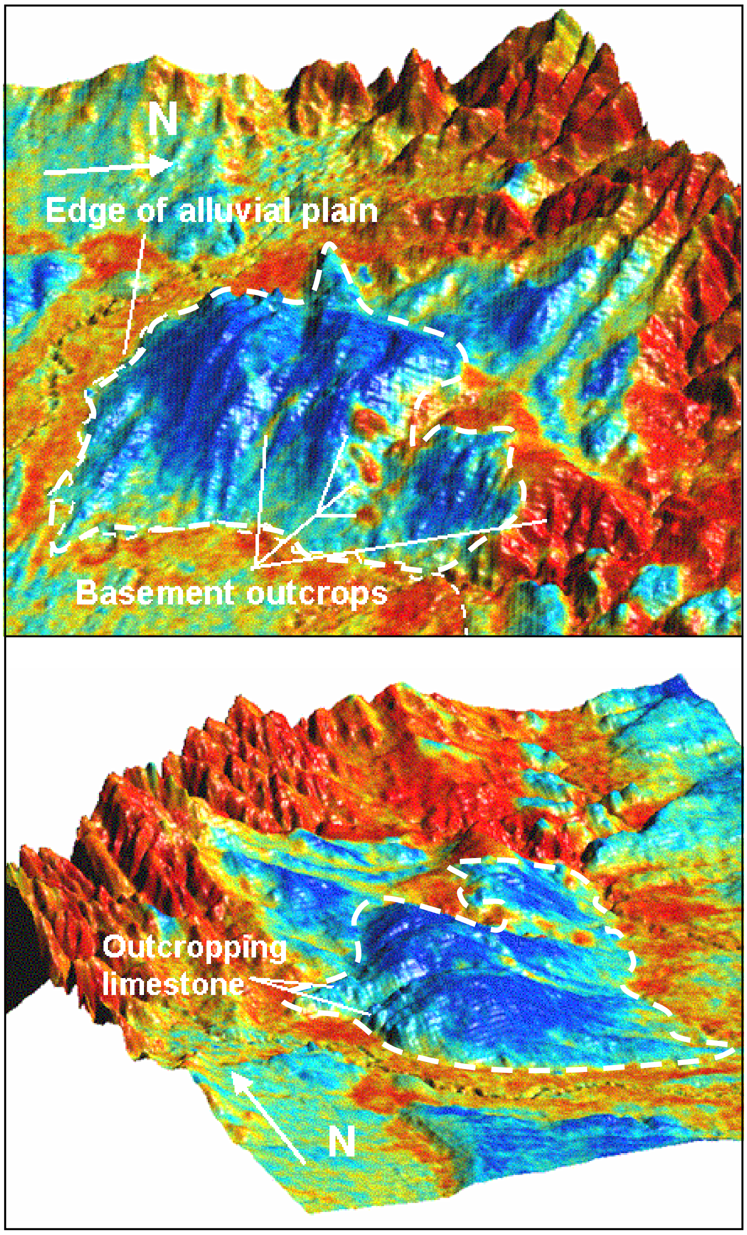
Maud (1972) presents a different history, interpreting that the Angas River originally flowed along the course of Sandergrove Creek, "probably behind a longshore dune related to the 200-ft sea level, to join the Finniss River at an elevation of 100 ft", implying that the ridge to the east of Sandergrove Creek is the remnant of this dune. Project drilling has shown that a palaeo longshore dune is not present, and given the structural interpretation of the area, it is considered unlikely that Sandergrove Creek ever flowed to the Finniss River.

7.3.8 Hydrogeology
Local landowners have indicated that groundwater in this area is present in both the sediments and underlying fractured basement rocks, and that water is brackish to salty. This is confirmed by the SA water database, which shows salinities varying from ~1500 to 11 000 mg/l. At least one landowner (Mr Dodds) is using groundwater to irrigate lucerne, and has recently (November 2002) drilled a new bore for irrigation (6627-10726). A major earthquake in the area in 1954 appears to have had an effect on local hydrology. Landowner Brian Eatts has indicated that a major saline scald developed on his property after the event, at about the break in slope between pediment and alluvial fan surface. Charles Michelmore stated that Sandergrove Creek often flowed before the seismic event, but has rarely flowed since, indicating a possible change in local hydrogeology. However, rainfall and runoff records need to be checked to see whether the change in flow occurrence could also be climate driven. It is probable that groundwater in sediments is pooled against basement (which should act as a barrier to groundwater moving eastward) on the east side of the Sandergrove Fault. There is most probably an unconfined shallow aquifer in clastic sediments and a confined deeper limestone aquifer.

7.4 Hills east of Strathalbyn

7.4.1 Landforms and materials
This unit is equivalent to the Burnlea and part of the Woodchester land systems of DWLBC (2002). The area has up to 80 m relief and mostly has very low radiometric response (Figure 54). Some steeper areas near Strathalbyn are characterised by outcrops of Tertiary limestone and well-formed closely spaced drainage lines, but much of the unit is characterised by gentle slopes, no rock outcrop and lack of well organised drainage. The DEM shows several dunes in the southeast. Areas of Tertiary limestone/clastic sediment have been mapped over some of the area, particularly close to Strathalbyn (Sprigg & Wilson 1954; Horwitz and Thompson 1960; Horwitz 1960; Thompson & Horwitz 1962; Hansen 1972). Hansen differentiates between actual outcrops of Tertiary sediment and areas with 'continuous calcrete cover', which he equates to subcrop of Tertiary material. He depicts much of the area as 'kunkarised' (i.e. calcreted) sand dunes, with no indication of the underlying lithology.

It is considered that much of the existing mapping of surficial materials in this area is inadequate. The Echunga 1 mile map (Sprigg & Wilson 1954) shows only basement and areas of Tertiary sediment over the northern part of the area, whereas the adjoining Milang sheet (Horwitz & Thompson 1960) shows areas of Tertiary sediments and a variety of surficial units that have very broad legend descriptions. The 1:50 000 soils maps (DWLBC 2002) give details of some of near-surface regolith materials present.



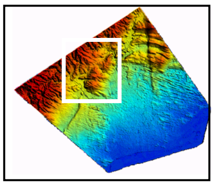
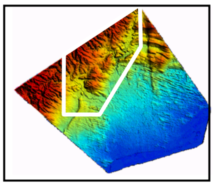


Figure 54. Oblique views of Potassium radiometric channel draped over radar DEM centred over the low hills east of Strathalbyn. Boundary of the Low Hills unit is shown as a white dashed line. Basement outcrops appear as areas of local relief with high radioelement response



The generally low radiometric response suggests that most of the area is not characterised by soils or sediment derived directly from basement. However, there are several areas of basement subcrop and outcrop with high response. A narrow southeast-trending area between about 313600 E 6096400 N and 314400 E 6095800 N has high radiometric response (particularly K). This small area is depicted as being underlain by basement rocks on the 1:50 000 soil map. A larger area of basement subcrop and outcrop along a major southeast trending valley across the unit also has mostly high response, with areas of low response within the valley interpreted as being alluvial sediment derived by reworking of Tertiary materials.

Scattered outcrops, sparse drill hole information, sections exposed in quarries and pits east of Strathalbyn and study of the radiometric response draped over the DEM in 3D suggest that the area is characterised by a draped veneer of Tertiary sediment, possibly partly reworked by wind and sheet flow, over basement. Tertiary limestone crops out around the western margin of the unit, and is associated with thick calcrete in soils. The limestone directly overlies basement in several places (a basement outcrop directly underlying limestone is depicted ~ 1 km east of Strathalbyn in Figure 27), but the limestone is underlain by poorly cemented ?estuarine sand, silt and gravel (unknown thickness) further to the east in quarries and waste disposal pits south of the Strathalbyn-Woodchester road (author's observations). Project drill hole AB07, drilled on the eastern foot slopes of the unit, intersected 11 m of silty sand with basal pebbly sand (Appendix 12). Driller's logs record up to possibly 17 m of sediment in higher elevation parts of the unit (eg drill hole 6627-1147, Appendix 7), and up to 35 m (6627-7659, Appendix 7) is present on the eastern flanks of the unit. Two cross-sections across the unit are shown in Figure 35 sections C-M and E-M. The depicted thickness of sediment away from drill holes is interpretative, but the available information points to a veneer of sediment over the east-facing slope of the northern part of the area (but basement subcrop on most of the adjoining west-facing slope), whereas the southern part of the area has almost complete cover. The southeast trending valley across the unit has eroded through the cover to expose basement (Figure 54). The AEM data show most of the area to be relatively resistive even at shallow depths, probably as a result of low moisture contents in the sediment and relatively shallow basement.

The distribution of low K surface material in the northern part of the area suggests presence of a veneer of gently east-dipping Tertiary sediment (presumably mostly sand and other clastic sediments that were deposited prior to limestone). However, the southern area is more complex, with basement contact present at elevations of up to 94 m in bore 6627-8953 (6 m of sediment, Appendix 5) near the crest of the hills, but down to 56 m in 6627-5774 (Appendix 7) just west of the unit (see Figure 35 section E-I). The distribution may be due to presence of a palaeo-rise in the area prior to Tertiary deposition or deformation after deposition. There has most probably been tilting (see section above on structural development of the area), but there is no evidence of post-sedimentation displacement along the proposed northern extension of the Sandergrove Fault through the area. The locus of the EM anomaly thought to represent the fault passes beneath outcropping Tertiary limestone that shows no sign of displacement (immediately south of the Strathalbyn-Woodchester road). Thus it is concluded that the southern area was a palaeo high prior to deposition. However, it is not easily explained why the modern eroded landform, which should bear no relation to the palaeo landform as it is eroded almost entirely into cover sediment, appears to mimic the pre-sedimentation ground surface.

DWLBC (2002) has suggested that the Blanchetown Clay is present at depth across the eastern slopes of the unit. This interpretation is not supported. There may be a clay unit, but it is not part of the Blanchetown Clay stratigraphic unit as defined – this was deposited in the palaeo Lake Bungunnia (Stephenson 1986) which existed some distance to the northeast of the area.

7.4.2 Hydrogeology

Groundwater within this area is probably mostly within fractured basement rocks, but areas of thicker Tertiary sediment could also contain water. Project drill hole AB07 appeared to have saturated gravelly sand at the base of the sedimentary section, and the hole had standing water at its base during wireline logging immediately after drilling. Water quality in 16 bores in the SA groundwater database varied from ~2500 to 20 000 mg/l (average ~7500 mg/l). It is possible that salt is stored in the regolith (Tertiary sediments, reworked sediment, and weathered basement), and this is being remobilised since clearing. The AEM indicates that the conductivity of materials in the top 15 m over all but the southeast of the area is mostly <20 ms/m. This appears to not support the presence of salts within the regolith, but if the material is dry, the salt content will not result in high conductivity.

The sandy sediment across much of the area may allow relatively rapid deep drainage. Slope gradients suggest radial groundwater gradients in this area. Interpretations of geology in the SA drill hole database suggest that Tertiary material is absent beneath Quaternary in drill holes in the Angas Bremer alluvial plain near its western margin with this area, but the thickness of interpreted Quaternary sediment can be quite large (eg 50 m in 6627-8696, Appendix 4). It is suggested, as shown in Figure 55 and Figure 35 section E-M, that the Tertiary clastic sediment may not be completely eroded at the margin of the alluvial plain, being preserved as a previously unidentified layer beneath the Quaternary. Thus it is suggested that the semi-confined limestone and underlying clastic sediment aquifer beneath the alluvial plain has a hydrological connection with the sandy cover over this unit, and has the potential to be recharged from deep drainage moisture in the unit moving laterally beneath the finer alluvial plain sediments.

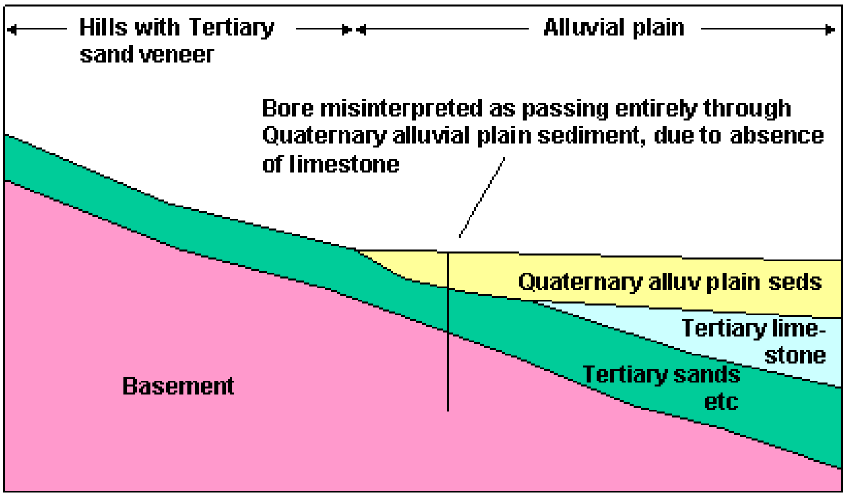


Figure 55. Suggested stratigraphic relationships at the northeast edge of the Angas Bremer alluvial plain where it adjoins the low hills east of Strathalbyn

7.5 Milang dunefield

7.5.1 Landforms and materials

This area has very low local relief, and slopes gently to the southeast (Figure 56). Its western boundary is the top of the west-facing scarp of the Sandergrove Fault. To the northeast and east is the alluvial plain of the Angas River, which has been incised into the area of the dunefield to the northeast, but is gradational in the east. It is equivalent to the Milang land system of DWLBC (2002).

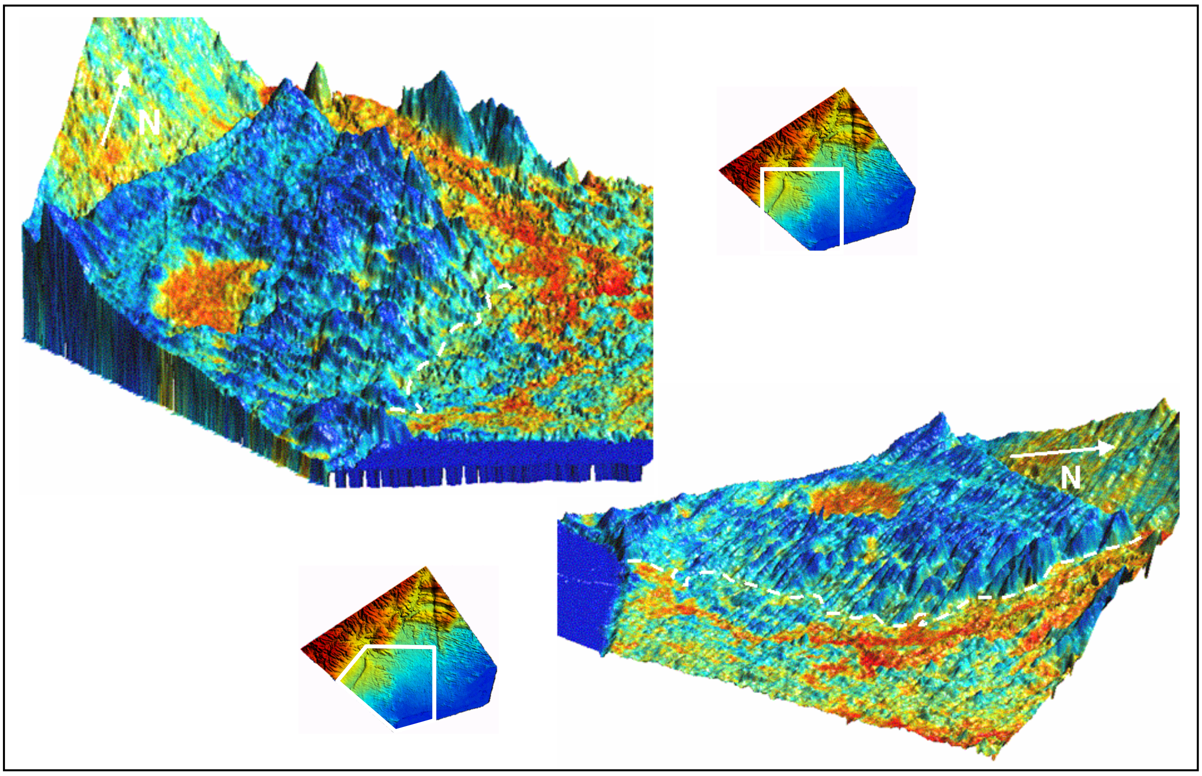


Figure 56. Oblique views of the Potassium radiometric channel draped over radar DEM centred over the Milang dunefield with extreme vertical exaggeration. Elevation of the dunefield varies from ~60 m in the north to near sea level in the south. The boundary with the Angas-Bremer alluvial plain is shown as a dashed white line. Longitudinal sand dunes with low K response dominate the landforms, apart from a large area with clay soils with high K response that is a deflation feature forming a window into the underlying ?early Quaternary sediments. Other smaller areas of high K are present in swales, and may represent small windows through the sand, or recent accumulations of clay washed into the swales

There are no drainage lines. Much of the area has a surface veneer of aeolian sand, organised into low east-southeast trending dunes. Radiometric response is mostly low, reflecting the sandy surface materials. However, there are one large and several small low-lying areas with clay soil characterised by gilgai (DWLBC 2002) that have a high radiometric response. It is interpreted that these areas are where the sediment underlying the sandy veneer is exposed, due to deflation. The radiometric response across the sandy areas shows minor variations that coincide with dune crests and swales and also very low relief broad wavelength topographic features roughly normal to the dunes. Thus the radiometric response appears to have the potential to provide a basis for mapping near-surface soil materials.

There are few deep bores with geological data to give an idea of the underlying structure, and these are mostly in the southeast half of the area. The available data indicate that the aeolian sands are underlain by Quaternary clayey sediments to a depth of 15-25 m, mostly underlain by Tertiary limestone and associated sediments which thin to the northwest. Project drill holes AB03 and AB04 (Appendix 12) show that the Tertiary sediments pinch out near the western boundary of the area. The Quaternary sediments have not been dated. It is probable that they are continuous with the ?Early Quaternary Currency Creek Formation of Maud (1972), defined several km to the southwest of the study area. Grainsize analyses from project holes AB04 and AB10 (near the eastern boundary of the unit) show that the sediments are mostly a mixture of fine sand, silt and clay. However, the bottom 4 m in AB10 is mostly green to grey sand. A sample of this material was processed for possible palynomorphs, but none were preserved.

McPharlin (1973) carried out a north-northwest trending line of nine resistivity soundings across the area. These suggested basement at 20-30 depth m (RL of 0 to +10 m) in the northwestern half of the line, dropping rapidly to ~160 m depth (RL of about –120 m). However, the depth profile suggested from this survey does not particularly match the depth to basement in drill holes. Drill hole DM16 (6627-864) (Figure 35 section G-L), which is roughly in the centre of the area, has basement elevation of -40 m (Appendix 9), but is between two soundings that have suggested basement elevations of about -120 m. Bore 6627-7198, about 2.5 km to the south-southeast (not near a resistivity sounding) has basement at an RL of –98 m. Thus the limited bore information suggests basement deepening to the southeast, but at a much higher elevation than suggested by the resistivity soundings. Williams (1978) has suggested that a northeast-trending fault crosses the area, truncating the Tertiary limestone aquifer (see Section 6.1.4). There is no evidence for this fault in the AEM CDI data, and Tertiary limestone is now known to extend to close to the western margin of the area (project hole AB04, Appendix 12; Jones *et al*. 2003), well west of the proposed fault. Sections G-L and H-K in Figure 35 show the interpreted structure of the area. There is a zone of rapidly rising basement, as demonstrated by data from holes 6627-864 and 6627-9167. Between these holes basement elevation rises by 26 m over 370 m distance. This could possibly be due to faulting, but also could be a result of warping or relief on the unconformity surface – a dip or slope of 4° is all that is required to explain the depth to basement data. The CDI depth and elevation slices show no evidence for a fault in the area, so a slightly steeper dip on the basement surface (due to either warping or relief prior to deposition, as shown in Figure 35 Section G-L) is favoured.

The source or mode of deposition of the ?Quaternary sediment beneath the aeolian sand is not known, but it is assumed it is derived from the ranges to the west. This area is now raised above the depositional plains associated with Sandergrove Creek and the Angas River. As it is proposed that the area has been tilted and raised by faulting, the sediment must relate to a depositional system in place prior to faulting. The area may have been part of a fan/floodplain of the palaeo Angas River and other smaller watercourses emanating from the ranges to the west. Under this scenario, the Angas River would have cut an antecedent valley through the rising ridge immediately east of the fault, but smaller watercourses from the ranges further south were diverted along the foot of the fault scarp (i.e. the fault angle depression), forming Sandergrove Creek. The antecedent valley of the Angas River has now been partially filled with alluvial deposits, forming the constricted part of the alluvial plain between this unit and the hills east of Strathalbyn. This is shown in Figure 35 section G-L.

Thompson & Horwitz (1962) depict at least part of this area as an inclined Pleistocene surface, but the author is not aware of any implications these authors may have attached to this interpretation. Maud (1972) postulated that the ridge in the western part of the area was a longshore dune, but project drilling (AB03) and the AEM demonstrates that it results from faulting.

DWLBC (2002) has suggested that the Blanchetown Clay and Currency Creek Formation are present across the unit. There is a sandy clay unit which drill hole information suggests covers the area, but it is not part of the Blanchetown Clay stratigraphic unit as defined – this unit was deposited in the palaeo Lake Bungunnia, which existed some distance to the northeast of the area (Stephenson 1986). The material is probably better to be referred to the ?Early Quaternary Currency Creek Formation (Maud 1972) which is described as being predominantly sandy clay. Grainsize analysis from project drill hole AB04 shows that much of the sediment is composed of sand, silt and clay in roughly equal proportions (Appendix 14). The low lying areas with high radiometric response are most probably locations where there is a window in the aeolian sand cover resulting from deflation, with soils formed directly from clayey Currency Creek Formation.

7.5.2 Hydrogeology

The Tertiary limestone aquifer is confined by the overlying ?Early Quaternary sediments. However, in the west of the area, the limestone is not saturated (eg in project drill hole AB04, Jones et al. 2003). This is not surprising, considering that the elevation of the base of the aquifer in AB04 is at ~ +8 m, whereas the potentiometric surface at DM16 (6627-864), further down slope, is ~ +2 m. TDS of bore water over most of the area varies from ~5000 to 15 000 mg/l, although lower values are present near the eastern boundary with the Angas-Bremer alluvial plain. Water level data in the SA water bore database and elevations of bores calculated from the DEM suggest that the piezometric surface of the confined aquifer is only slightly above sea level over most of the area.

7.6 Hills east of the Bremer River

7.6.1 Landforms and materials

This area has elevation of up to ~165 m, with slopes of up to 10% and local relief up to 70 m. Sand and calcrete dominate surface regolith along the two public access roads in the area. Radiometric response is low, suggesting these materials extend across the area (Figures 57, 58).

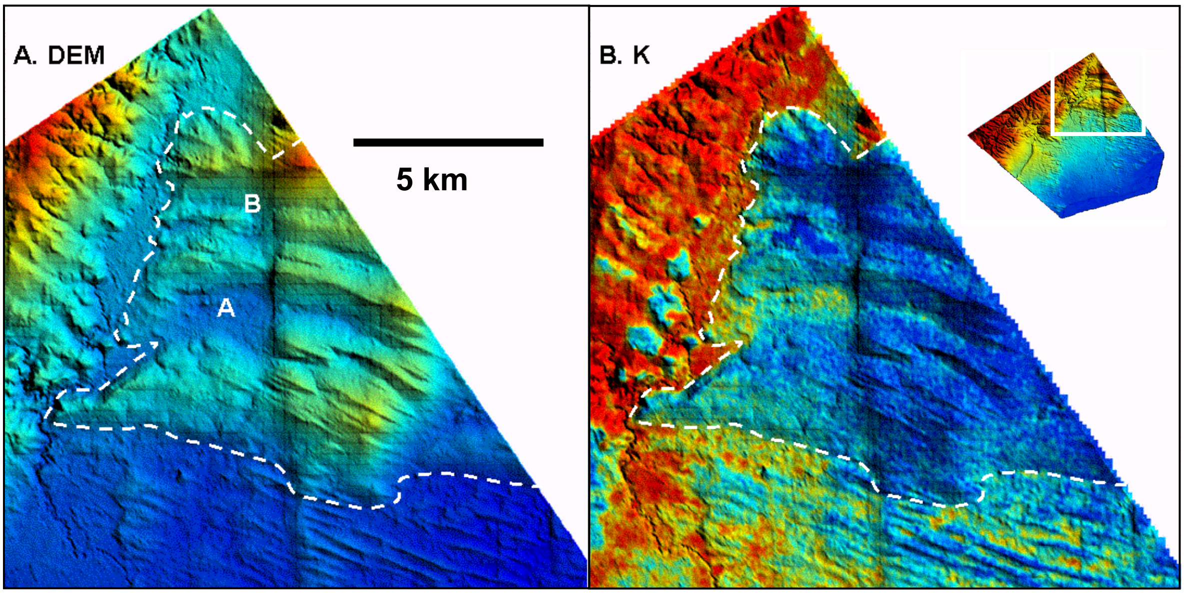


Figure 57. Hills east of the Bremer River. A. radar DEM. B. Potassium channel of radiometrics over greyscale DEM with illumination from the northeast. Boundaries of the area are shown as white dashed line. Locations A and B are areas of internal drainage (see Figure 59). Modern linear dune crests show as sharp features in the east of the area; some of these are slightly oblique to Pliocene barrier dunes present as high relief broad wavelength features in the east

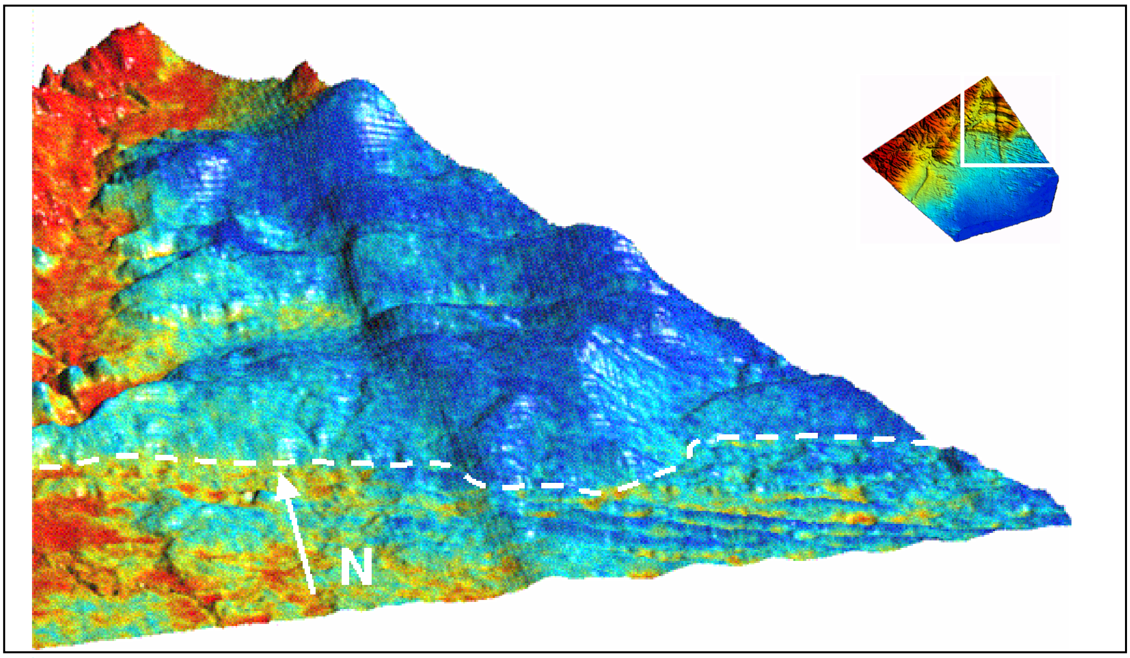
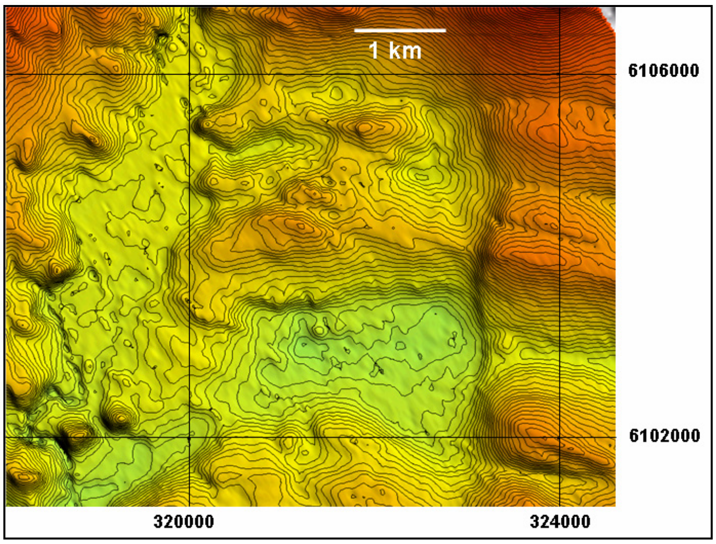


Figure 58. Oblique view of Potassium channel of radiometrics draped over the radar DEM, showing the hills east of the Bremer River. The southern boundary of the area with the low lying dunefields to the south is shown as dashed white line. Elevation ranges from ~20 m on the low lying dunefields in the south to 165 m in the north.

The Bremer Fault is expressed as a north-trending lineament, which extends onto the linear dunefields to the south. The landscape appears to have been vertically offset (east side up) across this feature, indicating some relatively recent movement (in geological terms). Two east-west oriented valleys west of the fault that appear on first glance of the DEM to slope towards the Bremer River in fact have areas of internal drainage (A and B on Figure 57, Figure 59). These anomalous landscapes could be the result of sink holes in the Tertiary limestone, which from scattered drill data appears to be close to the surface in the valley floors. However, it is considered more likely that they are valleys that were originally west-draining, but have been tilted down to the east during fault movement to form local sunk lands. Data from drill holes and the AEM show that there is a much thicker Cenozoic section west of the fault, with up to 80 m offset of basement (Figure 35 section BJ). The AEM data show sharp discontinuities at the fault, with little variation in east-west spatial location, indicating that the Cenozoic strata have been offset by a near vertical fault rather than deposited against a partially eroded pre-existing fault scarp.



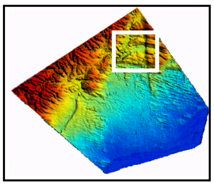


Figure 59. Detail of radar DEM with 2 m contours, showing areas of internal drainage west of the Bremer Fault. The upper alluvial plain of the Bremer River is in the left of the scene, and the channel of the river is visible in the lower left. The internal drainage areas are interpreted to result from downwarp west of the Bremer Fault due to faulting.

Airphoto interpretation by the author and information from S.A. Barnett (1994), Brown & Stephenson (1991) and mineral exploration drill holes (Appendix 8) indicate that the area to the east of the Bremer Fault is made up of palaeo barrier dunes of the Pliocene Loxton-Parilla Sands over thin Tertiary limestone. A maximum of 26 m of sand is recorded in mineral exploration drill holes, and there is the potential for much thicker sand sections at dune crests – sections A-M and B-J in Figure 35 suggest a maximum of > 50 m. Airphoto interpretation and information on the DEM show that low modern linear dunes are superimposed on the old barrier dunes (Figure 57).

West of the fault, variable clastic sediments (including clays and gravels) overlie Tertiary limestone and associated sediments, which thicken to the south and east. For example, hole 80 HRM 12 (6727-2369, Appendix 5) intersected 14 m of sand, clay and calcrete over 10 m of quartz rich gravel over limestone. The age of the sand, clay and gravel is not known. This sediment is now being eroded, and is not part of the modern alluvial deposits of the Bremer River. It may represent a shallow marine facies equivalent of the Pliocene barrier dunes, with gravel clasts brought into the area by a palaeo Bremer River, or could be part of the Oligocene-Miocene sequence (it is shown as being equivalent to the barrier dunes in section B-J, Figure 35). The Tertiary limestone crops out along the western margin of the area, in slopes abutting the alluvial plain of the Bremer River.

7.6.2 Hydrogeology

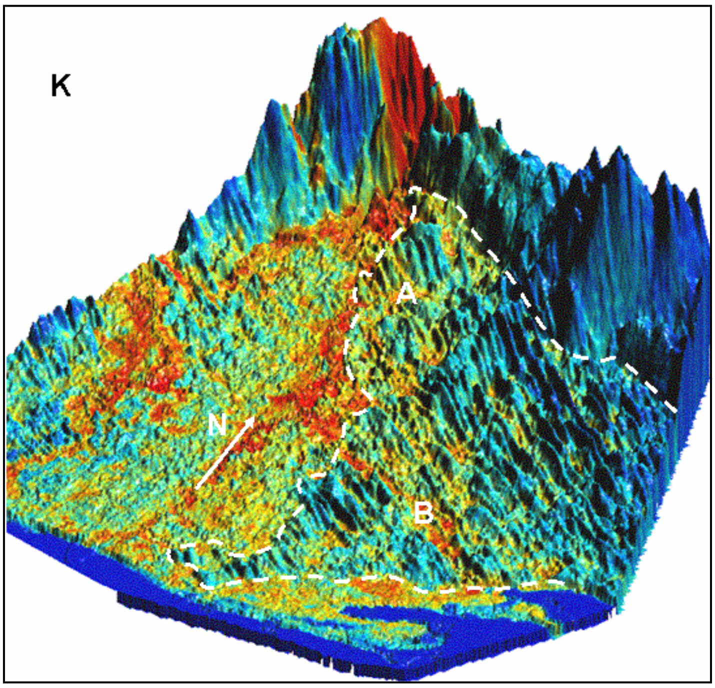
24 bores recorded in the SA groundwater database in this area have salinities ranging between ~2000 and 21 000 mg/l, and a local landowner has reported to the author salinity of 1900 mg/l in one of his bores in the western part of the area. Thus there is potential for pockets of reasonable quality water across the area The 3D geological structure of the area, with limestone overlain by Loxton-Parilla Sands and possibly younger sands at least in the eastern part of the area, suggests that vertical recharge from rainfall to the limestone aquifer might be possible via the overlying sandy material. In addition, it is possible that recharge may occur at the western margin of the unit where the limestone aquifer abuts or possibly underlies Quaternary alluvium of the Bremer River (Figure 35 section B-J). Areas of internal drainage west of the Bremer Fault might act as recharge zones, depending on rainfall and permeability of near surface materials. East of the Bremer Fault, the Tertiary limestone aquifer should be unconfined, but it may be partly of fully confined west of the fault.

The AEM data show considerable conductivity variation in Cenozoic sediments across this unit. Figure 13 suggests that reasonable quality water might be locally present. The DEMs allow the approximate elevations of water bores in the SA water database to be estimated, and using the water level data in the database, it should be possible to estimate the potentiometric surface, at least in the western part of the area where most of the bores are. Initial calculations point to a southerly inclined surface. However, if recharge is occurring from the Bremer River, via Quaternary alluvium along the west boundary of the unit, the slope of the potentiometric surface might have an easterly component. If this is the case, the Bremer Fault might have an effect on groundwater flow, and possibly act as a boundary against which deeper groundwater is ponded. The Bremer Fault also separates areas with deep basement in the west from shallow basement in the east (Figure 35, sections A-M and B-J).

7.7 Dunefield east of the Angas-Bremer alluvial plain

7.7.1 Landforms and materials

This area is a relatively low lying plain, dropping in elevation from 20-30 m at its northern margin, to just above sea level at Lake Alexandrina (Figure 60). It is characterised by east-southest trending longitudinal sand dunes up to ~10 m high. Radiometric response is variable, with dunes having low response, and swales variable, up to quite high response. This variation most probably reflects the sand to mud ratio at the surface, and could be useful for more detailed soil mapping in the area. Road cuttings and surface lag indicate that many of the dunes have been heavily calcreted. The lineament associated with the Bremer Fault extends into the northern part of the area, where it is characterised by a linear west-facing low angle scarp up to 20 m high. There appears to be no organised drainage across the area, apart from Mosquito Creek, a flood distributary of the Bremer River. Study of the DEM shows that northern parts of the area west of the Bremer Fault locally have elevation lower than the adjacent alluvial plain. Source bordering dunes east of the Bremer River prevent the flow of floodwater and alluvial sediment to these areas, thus containing the area of alluvial plain.



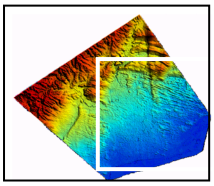


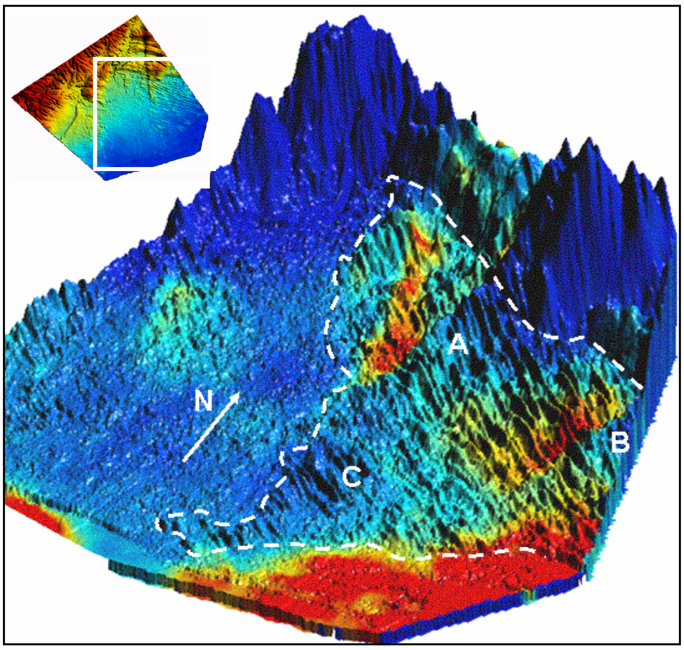
Figure 60. Oblique view of Potassium radiometric channel draped over radar DEM with extreme vertical exaggeration, showing the longitudinal dunefield east of the Angas-Bremer alluvial plain (boundary shown by the white dashed line). Low lying areas at A are at a lower elevation than the nearby alluvial plain. Linear high K area at B corresponds with the channel and close environs of Mosquito Creek, a flood distributary of the Bremer River

Bores across the area are interpreted (SA stratigraphic database; Appendix 4) to have intersected mostly around 20 m of Quaternary sediments, mostly fine grained, overlying Tertiary limestone and related sediments. A database thickness of 48 m in 6727-2238 appears to be in error (Appendix 4). The depth to basement varies markedly across the area (see sections in Figure 35. AEM and drill hole data indicate that depth to basement has been offset by ~ 50 m across the Bremer Fault northwest of Langhorne Creek, but this offset declines to the south. AEM data do not indicate offset south of Langhorne Creek, and drill holes are too widely spaced to use depth to basement to indicate whether there is offset.

Brown & Stephenson (1991) extend the distribution of a ~0.8-0.9 Ma age algal dolomite (their lagoonal Qpu unit) best known from the area east of Tailem Bend (on the Murray River, ~20 km east of the study area) into this area (their Figure 128), and have interpreted it in several bores east of Langhorne Creek (Brown & Stephenson 1986; bores 6727-1445, -1456, -1470 and -1482, Appendix 11). However, information recorded on bores in the area in the SA drill hole database (Appendices 4, 5) indicates that the upper unit consists of variable sand, silt and clay, with the only carbonate being calcrete. Therefore Brown & Stephenson's interpretation appears to be in error in this area.

7.7.2 Hydrogeology

Salinity contours of the groundwater in the confined limestone aquifer are not shown for the northern part of this area in publications on the hydrology of the Angas-Bremer Plains, but there is the implication that it is mostly saline. The SA water bore database shows that water salinity can exceed 30 000 mg/l in this area. The author has observed saline discharge in swales to the east of the study area, and salt is commercially harvested at one of these sites. However, brackish water up to 3000-4000 mg/l is present south of Mosquito Creek (e.g. Carosone & Cobb 1975). This area of intermediate salinity is reflected by an area of relatively low AEM conductivity at depth (location C in Figure 61 and Figure 11).



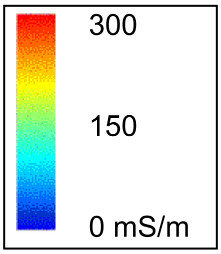
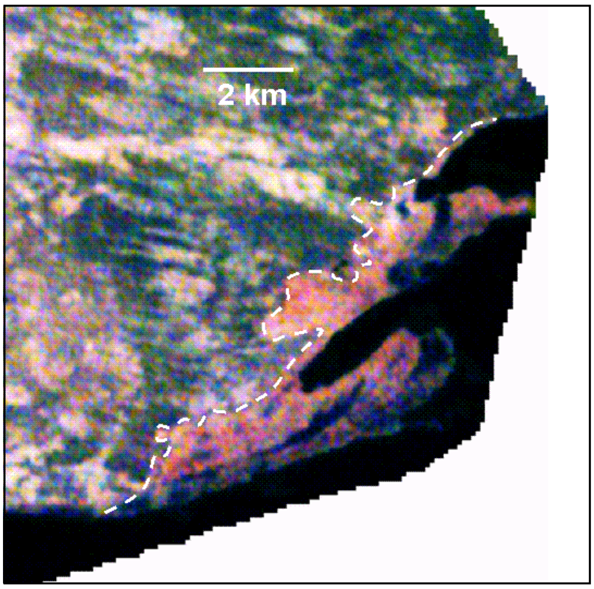


Figure 61. Oblique view of AEM conductivity for 55-60 m depth (0-300 mS/m linear colour stretch) over DEM. Resistive areas at A and B are due to shallow basement east of faults, at C due to lower salinity brackish groundwater south of Mosquito Creek.

7.8 Lake Alexandrina marshes

7.8.1 Landforms and materials

Figures 60 and 61 show a zone of very low relief adjacent to Lake Alexandrina south of the dunefield described above. Radioelement response in this zone is locally fairly high (Figure 60), but ternary images (Figure 62) show a dull red grading to dark response. This area corresponds to areas of marsh adjacent to the lake shore. It is probable that some of the surface sediment is wet, leading to attenuation of radiometric signal. The outline of the shoreline, with lobes to the east suggests that the landform has accumulated through trapping of sediment transported eastwards from the mouth of the Bremer River by wind driven currents and wave action.



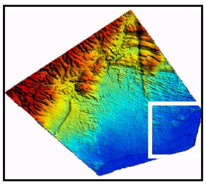


Figure 62. Ternary (red=K, green=Th, blue=U) radiometric image of southeast of study area, showing areas of shoreline marsh with dull red to dark response (southeast of white dashed line), and lobate shoreline interpreted to result from eastward transport of sediment from the mouth of the Bremer River. Very dark areas close to the lake (black response) probably have high near surface moisture, attenuating the radioelement response.

There are also minor areas with similar reddish radiometric response along the shoreline between the mouths of the Angas and Bremer Rivers, and immediately west of the River Angas. Brief field examination shows that narrow marshes are present along the coastline, and it is probable that these reddish areas represent some of the marsh areas. These minor areas are included as part of the Angas-

Bremer alluvial plain. Sediment of the marshes has been mapped as St Kilda Formation (Brown & Stephenson 1991). Work by Altmann (1976), Spagnuolo (1978) and von der Borch & Altmann (1979) confirms that this sediment is of Holocene age.

7.8.2 Hydrogeology

The AEM CDIs show that the entire sedimentary section of around 130 m in this unit is relatively conductive. Shallow conductivity could result from continual evaporation from shallow water tables concentrating salt, or ingress of lake water during a possible prior phase of saline or brackish water could be possible. Research by E.J. Barnett (1993, 1994) suggests that marine to brackish conditions occurred in the area of Lake Alexandrina prior to 6000 years bp, but that oligosaline to fresh conditions have predominated since that time. Well salinity data (SA water bore database) indicate that water from deeper holes is variably brackish, but very shallow holes (~2 m) have very saline water with up to 160 000 mg/l of dissolved salts.

7.9 Angas-Bremer alluvial plain

7.9.1 Landform

The Angas-Bremer alluvial plain is a complex low relief landform that is the result of alluvial deposition and erosion by the Angas and Bremer Rivers, aeolian winnowing and reworking of some of the alluvial sediment, and aeolian deposition of sediment derived from the dunefields to the west. The plain surface is slightly undulating with local relief mostly <3 m. The rivers are incised (up to 13 m for the Angas and 7 m for the Bremer estimated from the radar DEM) into the plain in upstream areas, and are classified as straight (as opposed to braided or meandering) rivers. The plain can be divided into two parts, a main triangular area with its apex in the north where the Bremer River enters from a bedrock-floored valley and base at the Lake Alexandrina shoreline, and a confined alluviated valley ~ 2km wide and 8 km long along the River Angas between Strathalbyn and the main plain (Figures 63, 65).

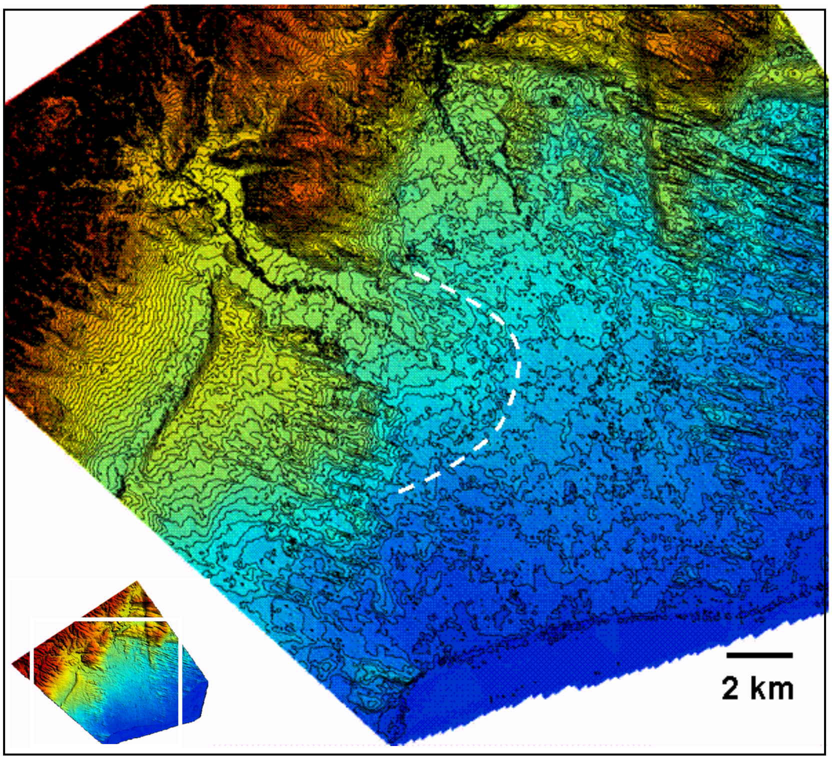


Figure 63. Radar DEM with 2 m contours centred over the Angas-Bremer alluvial plain. The main area of the plain along the course of the Bremer River shows relatively evenly spaced contours, as suggested by the profile in Figure 64. However, the steeper confined alluvial plain along the upper Angas continues as a lobe which appears to be prograding onto the rest of the plain (approximate edge of lobe shown in white). The northern edge of this lobe is characterised by low longitudinal grading to source-bordering dunes.

The average gradient on the surface of the plain along the course of the Bremer River is 1.8 m/km, but the Angas plain has gradients of 4.6 m/km immediately downstream of Strathalbyn, dropping to 2.9 m/km, and then 1.2 m/km for the last 6 km (Figure 64). The steeper gradient has allowed deeper incision of the River Angas in the upstream area. The Bremer River has a natural channel to Lake Alexandrina, but the lower Angas has an artificially excavated channel. Prior to excavation, it flowed into swamps. This behaviour reflects the low gradient on the lower part of the plain around the Angas. The steeper confined alluvial plain of the upstream Angas River continues as a lobe onto the lower angle slope of the main plain (Figure 63). The northern edge of this lobe is characterised by low dunes, some of which appear to have sand sourced from the low hills to the west, but also some are slightly oblique to the linear dune direction, and appear to be source-bordering dunes (Figure 65). The rivers are not permanent flowing, with water reaching Lake Alexandrina generally only during winter or in times of flood after heavy rain. At other times, they lose flow across the upper parts of the alluvial plain by evaporation and seepage into groundwater. Mosquito Creek (which flows east from Langhorne Creek – see Figure 4) is a flood distributary of the Bremer River, and has a channel through dunefields to the east of the alluvial plain.

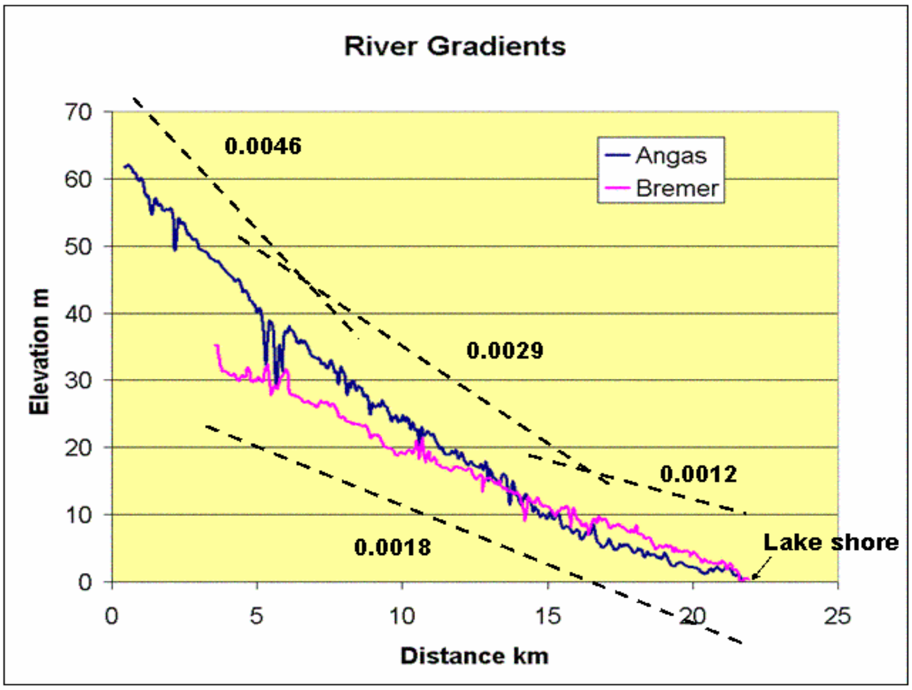


Figure 64. Profiles of the alluvial plain surface along the course of the Angas and Bremer Rivers from the radar DEM. Local variations are due to presence of sand dunes and levees, and the incised channel of the rivers (particularly Angas River at about 6 km). Section for the River Angas starts at Strathalbyn, for the Bremer River at the head of the alluvial plain. The Bremer profile has a fairly steady gradient of 0.0018, but the Angas profile can be divided into three segments with gradients of 0.0046 to 0.0012.

The undulating surface of the plain is largely due to presence of local aeolian landforms (Figure 66), but is also locally due to terracing (especially near the Bremer River in the north), and presence of broad natural levees along the rivers, particularly the Angas (Figure 65). Some of the elevated sand bodies on the plain are aligned parallel to the linear dunes in the adjoining dunefields, some are elongate source bordering dunes to the east of and roughly parallel to the watercourses, whilst others are more equant in plan shape and cannot be directly attributed to a local sand source (eg a ~200 m diameter mound 2-3 m high at 320900 6093350 near the west bank of the Bremer, visible from the Langhorne Creek-Woodchester road). There is also the possibility that some of the raised sandy areas are old levee deposits or channel fills which now stand above the plains. Low lying areas of the plain are characterised by finer textured sediment. A preliminary comparison of the radiometric response and microrelief/soil texture across this area indicates that the radiometrics should be a useful tool for making a more detailed soil map than is currently available (DWLBC 2002). The areas with highest radiometric response mostly occur in low lying areas, and appear to depict areas of relatively recent (but probably dating back well before European settlement) flooding which has deposited silty muscovite-bearing alluvium (Figure 65). Sandy (quartzose) rises have low radioelement response.

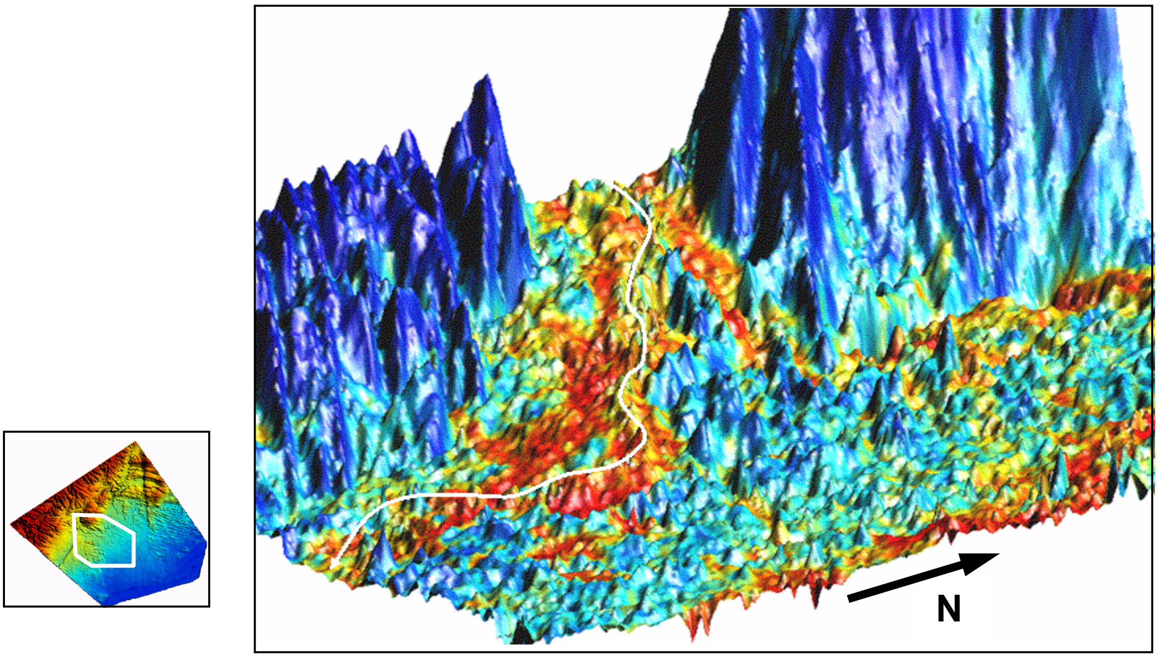


Figure 65. Oblique view of K channel radiometrics over the radar DEM (with extreme vertical exaggeration) looking northwest from the lower Bremer River area to the upper confined Angas alluvial plain. The course of the River Angas is highlighted in white. Note dunes to the north of the Angas where it leaves the confined valley (relief up to 4 m), and slope down to the northeast from the Angas to the main alluvial plain. The Angas is bordered by natural levees, and thus appears locally to be flowing along a ridge. Dunes are characterised by low K response (quartzose sand); areas of high K response appear to reflect areas where flood waters have deposited silty muscovite-bearing alluvium.

Figure 66. Undulating surface of the western part of the Angas-Bremer alluvial plain, due to presence of low longitudinal dunes. The dunes are imaged by the radar DEM, and have low radioelement content compared with the lower-lying areas of the plain which are characterised by finer textured sediment. Location ~316600 6085100, looking north along the Strathalbyn-Milang road.

The boundary of the upstream confined Angas alluvial plain with the Milang Dunefield to the southwest is clear cut, with a marked break of slope (Figure 65). However, further south the boundary becomes gradational, with aeolian sand sheets and low dunes characterising the western part of the plain. The boundary with the low hills east of Strathalbyn is also a clear break of slope. The boundary with the dunefields to the east is variable. In the north, the alluvial plain appears to have been incised into an undulating dune covered surface up to 10 m higher than the plain. Further south, a series of source bordering dunes east of the Bremer River separate the alluvial plain from a longitudinal dune-dominated landscape that is locally lower than the adjacent alluvial plain by up to 8 m (from radar DEM data; location A on Figure 60). The source bordering dunes have prevented floodwater and sediment from reaching the low lying areas, and thus prevented eastward migration of the river.

The plain is in essence a low angle fan that is confined by higher ground to the west. The geometry of the Bremer River and Mosquito Creek, and shoreline of Lake Alexandrina (Figures 1, 4) suggests that the area could also be described as a delta with a convex shoreline between Milang and the eastern-most part of the study area. However, only the western 2/3 of the 'delta' area is occupied by the modern alluvial plain. Mosquito Creek is a flood distributary of the Bremer River that leaves the main alluvial plain to pass through the dunefields to the east and reach the lake at about the eastern margin of the 'delta'.

7.9.2 Sediments

Over most of the alluvial plain area, Quaternary clastic sediments up to ~40 m thick overlie a thin discontinuous layer of fine shelly sand (referred to the Loxton-Parilla Sands, known only from drilling, and probably Pliocene age) and thick Tertiary limestone and associated underlying clastic sediments. These various sediments have been well described in publications such as Williams (1978). The limestone and associated sands form an aquifer that is partially confined by the overlying units. The limestone has high porosity and permeability, mainly as intergranular voids (it is calcarenite, formed of detrital fragments of shelly fossils and to a lesser extent, quartz grains), but also possibly as solution features. The distribution of Loxton-Parilla Sands is not well known. Williams (1978) shows it to be very thick in drill hole DM 19 (6627-919) and to be present over a large area. However, the information in the SA stratigraphic database shows the ~23 m sand section in DM19 to be Quaternary rather than Tertiary, suggesting the sand may be part of the Quaternary deposits of the Angas River. Williams (1978) states that outcrops of sand in the banks of the Angas River upstream of Belvidere Bridge are assigned to the "Parilla Sand equivalent". These exposures have not been studied by the author. The thickness of the Quaternary sediments and structure contours of the Quaternary/Tertiary contact are known from numerous drill holes (eg Carosone & Cobb 1975; Appendices 4, 5 and 8). Basement is present at depths of up to ~ 130 m (Appendix 9). Some drill holes have intersected weathered basement, for example Bowden & Bleys (1971) report >50' (15m) of weathered phyllite, the top 20' (6 m) being completely weathered (now blue green clay) in DM1 (6727-1527).

South Australian Government drilling shows there is great variability within the Quaternary sediments, for instance Bowden & Bleys (1971) report marked lithological variation between two bores ~60 m apart. Williams (1978) reports that the sediments are mottled (i.e. have been weathered), bioturbated in part, and that gravels and sands usually occur in the lower part of the sequence, and are more common upstream. The sands are more angular than the underlying Loxton-Parilla Sands, and contain maghemite (Waterhouse & Gerges 1979). Several authors report disconformities and palaeosols within the sediments – these should be considered normal for an alluvial sequence. Seven soil pits in the area have exposed a variety of sedimentary materials (DWLBC 2002).

The author has observed the upper part of the sequence exposed in the banks of the incised River Angas at several locations. Red/brown silty very fine to fine sand predominates. Cross-bedded lenses of coarse sand with scattered gravel clasts and charcoal grains are locally present. There are also some more clayey beds. Rhizomorphic and/or powdery calcrete are present in some layers. A visual examination of core and cuttings from drill hole BRM 234 (6627-914) shows that red/brown and yellow micaceous fine silty sand predominates in this hole to 24 m (lower depth limit of samples held at the PIRSA Core and Cuttings Facility), with ~30% gravel from 22 to 24 m. Grainsize data from project drill holes AB05, AB06, AB08 AB09 and AB11 which intersected the Quaternary alluvial sediment (Appendix 14) show that fine to very fine sand and silt predominate in these holes. This grainsize range is consistent with the source areas for the sediment in the Eastern Mt Lofty Ranges, which consist largely of late Precambrian to Cambrian low grade metamorphic micaceous sandstone/greywacke and siltstone/phyllite/schist which for the most part have not been strongly weathered.

Maghemite has been observed by the author only in drill hole AB08. The log for drill hole 6627-8161 describes magnetic gravel (Appendix 5) in the upper part of the Angas River alluvial plain. The magnetic survey of the area (Figures 6, 19) revealed only very minor high amplitude noise that could be attributed to maghemite (apart from the vicinity of drill hole 6627-8161, Figure 20), and it is concluded that only very small amounts are present. Presence of maghemite implies erosion of areas of iron accumulation in weathered rocks in the catchment, but is not necessarily evidence for a "lateritic" ferruginous weathering profile in the catchment.

The thickness of Quaternary sediments and structure contours on the top of the Miocene aquifer have been previously depicted by Carosone & Cobb (1975) and Williams (1978). The interpretations in these two publications are broadly similar, in that the general alluvial plain area is shown to have thicker Quaternary sediment than the surrounding areas, but details are very different, with structure contours of the two interpretations often crossing at right angles. An up to date compilation of depths to the top of the limestone in drill holes is given in Appendices 4, 5 7 and 8, with elevations of the holes derived from the radar DEM. This should allow construction of a more detailed surface on the top of the limestone. At this stage it appears the base of the Quaternary sediments cannot be modelled from AEM data.

7.9.3 Depositional models

Many previous authors have stated that all the Quaternary sediments are fluvial to possibly lacustrine. However, their thickness means that much of the sediment, especially in the lower part of the plain, is below modern sea level. This implies that if the sediment is continental rather than marine/estuarine, either deposition has occurred at times of lower sea level, or that there has been downwarping of sediment originally deposited above modern sea level.

Structure contours on the top of the Tertiary limestone constructed from drill intersections (eg Carosone & Cobb 1975; Williams 1978) show a broad palaeovalley in the area of the modern alluvial plain, with closed depressions. It is possible that the closed depressions were either present at the time of onset of Quaternary deposition because of karstification of the limestone, or result from solution collapse of the limestone beneath Quaternary cover. Alternatively, the closure on the depressions may be in part an artefact of contouring of drill hole data.

A possible scenario for alluvial deposition is that the palaeovalley was eroded over times of depressed sea level, and that the sediments were deposited in response to rising sea level. However, the balance between deposition and erosion on the alluvial plain is dependant on sediment supply, sediment transport potential and trapping potential, with these factors dependent largely on climate, vegetation, base level (i.e. sea level), uplift of the catchment and possible downwarp of the basin (Figure 67). Thus there are many potential reasons for onset of Quaternary deposition or for fluctuating rates of deposition. Late Quaternary fluctuations in sea level and climate probably mean that there may have been multiple erosion/deposition cycles in the area. The author does not agree with Williams (1978) that changes in sedimentation regime relate specifically to periods of uplift of the ranges to the west.

Pre European sediment dynamics on the plain appear to have been vertical accretion of fine sediment from floodwaters on levees and more low lying areas, aeolian erosion and winnowing, aeolian deposition of sand sourced both from within the alluvial plain and the areas to the west, incision of channels and deposition of sandy to gravelly sediment along channels. It is suspected that the extreme incision of the Angas River downstream of Strathalbyn postdates settlement and clearing, which would have changed runoff and sediment yield from the catchment. The natural channels of the Angas and Bremer Rivers are fixed. It is probable that channel abandonment and erosion of new channels during peak floods has been a feature of the area over recent geological history, rather than semi-continuous lateral migration of channels.

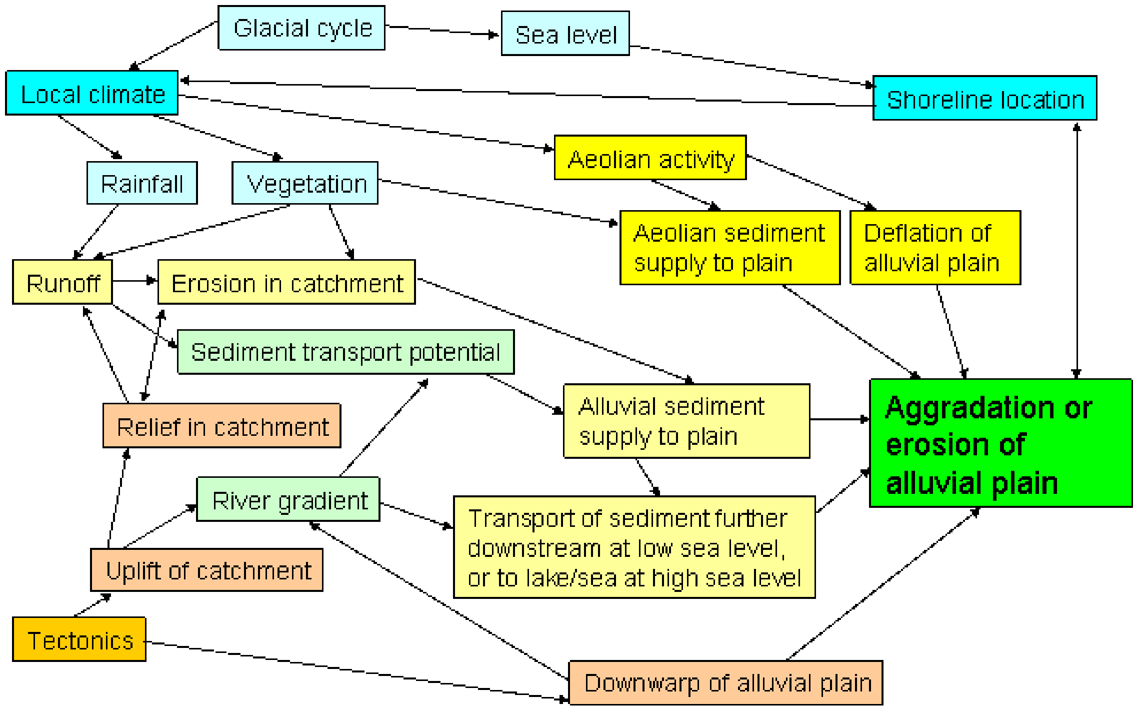


Figure 67. Inter-relationship of climate and tectonics in delivery of sediment to and removal of sediment from the alluvial plain

In the absence of any contra-indications, it is assumed that the modern style of river channel type predominated during deposition of the alluvial sediments, with fixed straight channels, broad levees and extensive floodplains. However, it is likely that the superimposed effects of aeolian erosion and deposition have varied considerably with climate. Although the channels are nominally fixed, they have probably at times filled with sediment plugs and a new channel formed in a totally different place on the floodplain. This channel behaviour contrasts with that of rivers with laterally migrating channels as are present in many watercourses in the Murray-Darling Basin, which may deposit broad laterally continuous sand bodies during point bar migration. Sand bodies within the Angas-Bremer alluvial sediment are likely to be either thin beds deposited on the floodplains during single flood events (interbedded with finer sediment), channel fills (which may be limited to metres in thickness, 10s of metres in width and kilometres in length), or possibly buried aeolian dunes, either source bordering parallel to the channels, or parallel to prevailing winds). The channel fills may also contain gravels. The depositional model of vertical accretion on floodplains with fixed channels (as opposed to lateral accretion by meandering channels) and a sediment source primarily of fine sand to silt rich rocks means that the distribution of thick sand and gravel beds is likely to be very limited.

At present there is no potential for erosion of deep channels in the lower part of the plain due to low runoff and the surface of Lake Alexandrina forming a local base level at about sea level. However, during Quaternary glacial periods when sea level dropped dramatically, the potential for deep incision of the river channels would have increased markedly. These channels would have filled with sediment as sea level rose, but it is considered likely that much of the fill could have been fine-grained, deposited under alluvial to estuarine conditions.

Alluvial swamps are locally present along the Bremer River (eg just downstream of Langhorne Creek), and the Angas River discharged to swamps before construction of an artificial channel near Lake Alexandrina. Swamp deposits with high organic matter and shelly fossils are exposed in the banks of the Angas River adjacent to project drill hole AB06. It is possible that laterally extensive alluvial swamp deposits are locally present through the Quaternary sediments. However, it may be difficult to distinguish these from fine floodplain sediments.

There is also the possibility that open water lake deposits of a palaeo Lake Alexandrina or some form of estuary of the Murray River system in place during previous interglacial periods when sea level was roughly at its present level might be present at depth, but to reconstruct the detailed palaeogeography of this area through the variations in sea level associated with Quaternary ice ages is outside the scope of this study.

The relationship between the Quaternary sediment beneath the alluvial plain and the sediment beneath the areas to the west and east is not clear. As none of the sediment (apart from a radiocarbon date of 3500 years, Dury 1964) has been dated, relationships are conjectural. As discussed previously, the Quaternary sediment beneath the tilted block between the alluvial plain and Sandergrove Creek (Milang Dunefield) must date back to a time prior to depositional systems being offset by movement along the Sandergrove Fault. The sediment on the tilt block may be contemporaneous with deeper parts of the sediment of the alluvial plain (i.e. sedimentation ceased on the tilted area due to uplift and removal of sediment transport pathways, but continued further down slope where the palaeo Angas and Bremer Rivers were depositing sediment). Alternatively the palaeo rivers may have eroded some or all the older Quaternary sediment prior to deposition of sediment beneath the modern alluvial plain.

7.9.4 Hydrogeology

The alluvial plain has been the main focus of groundwater studies in the area, as there is intense agriculture (viticulture, lucerne, dairy etc) with irrigation, and shallow water table in many areas. These studies are listed in the bibliography. Water quality in the limestone is fresh to brackish (least saline water is generally close to the river channels). The overlying clastic Pliocene to Quaternary sediments form an unconfined aquifer and a leaky confining layer to the limestone aquifer. Recharge to the limestone aquifer was thought by previous authors to be from the Angas and Bremer Rivers via this leaky confining layer, and also via an interpreted northern faulted margin of the groundwater basin (eg Howles 1990) (see discussion below). Infiltration from rainfall to the unconfined aquifer has been considered to be insignificant.

Williams (1978) implies that the veneer of Pliocene Loxton-Parilla Sands between the limestone and the Quaternary sediment is not a water bore drill target as the sand is too fine and thin, and states that it has hydraulic conductivities similar to the overlying Quaternary sediments.

The existence and geometry of the fault proposed by McPharlin (1973) and Williams (1978) is important for modelling of recharge to the limestone aquifer. As depicted by S.A. Barnett, Howles and Telfer et al. (Figure 30A), it should not affect recharge, as it does not intersect the aquifer, unless there is a zone of increased permeability in basement rocks along the fault which is in hydrologic continuity with the limestone aquifer. If it is as depicted by Waterhouse (1977b) (Figure 30B), there could be enhanced recharge at the fault if there is a conduit with high hydraulic conductivity through the alluvium. If it is in the location depicted by McPharlin and has had movement since limestone deposition (see author's interpretation in Figure 29), there is the potential to generate a zone of higher permeability where the fault intersects the limestone. If the overlying sediments have not been faulted (i.e. there was movement during the hiatus between deposition of the limestone and overlying sediments, but not since), there will be no zone of higher permeability within these sediments resulting from the fault. Even if there has been offset of the overlying sediments, there may not necessarily be a zone of enhanced permeability, due to the unconsolidated muddy sediment sealing the fault plane.

There is no evidence for this fault in the AEM data (i.e. no linear sharp lateral discontinuities in conductivity that would result from juxtaposition of lithologies with differing porosity) and it is concluded that although there may be basement faults in the immediate area (as suggested by the magnetic coverages), these have not been reactivated to offset the Cenozoic sediments. It is considered far more likely that the locus of McPharlin's fault is a hinge zone for uplift of the Mt Lofty Ranges.

Shallow AEM data show a zone of lower conductivity (implying either fresher water or reduced porosity/water content) beneath the Angas and Bremer Rivers within the Quaternary sediment (Figure 68), and it is interpreted that this is a zone of fresher water within the Quaternary, implying that recharge to the groundwater system occurs from river water along the length of the rivers where they cross the alluvial plain. The link between recharge to the Quaternary sediments and recharge to the semi-confined limestone aquifer is outside the scope of this study. However, the more upstream parts of the Quaternary sequence may contain more gravel beds (Williams 1978), and this could enhance recharge of the limestone aquifer in the more upstream parts of the plain in the region of the rivers.

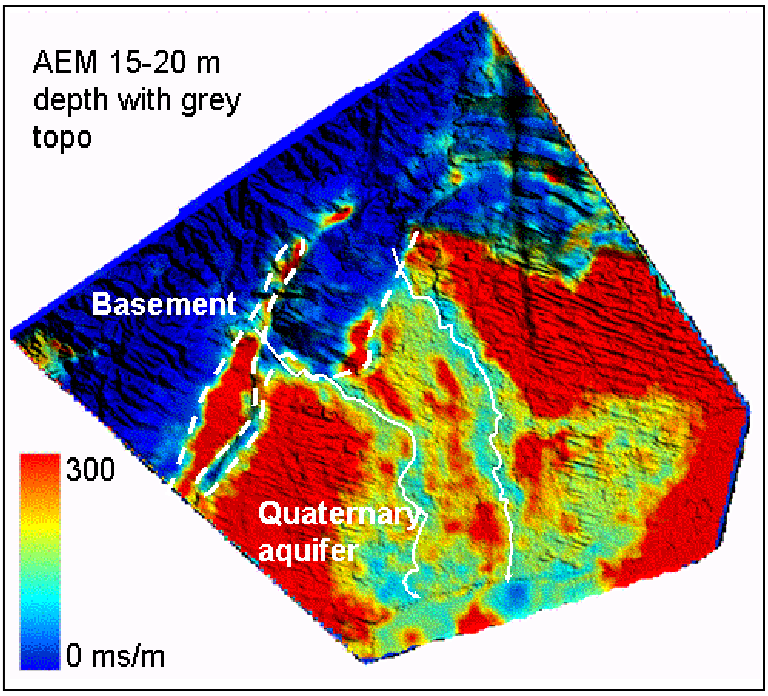


Figure 68. 15-20 m depth CDI conductivity with 0-300 mS/m linear colour stretch over greyscale DEM with illumination from the northeast showing zones of lowest conductivity along the Angas and Bremer Rivers (solid white lines). The approximate boundary between basement and Quaternary sediments at 15-20 m depth is shown by the white dashed line.

AEM conductivity within the limestone aquifer beneath the plain is dominantly low. However there is a relatively high conductivity (up to 200 mS/m) anomaly between about 316500 6092500 and 318000 6089500, near the western margin of the alluvial plain north of the River Angas (Figure 14). There are no observation bores into the limestone aquifer in this area, but bore 6627-914 with depth of 55m, and which intersected the top of the Tertiary limestone at 39.4 m (Appendix 4) is shown in the SA water database as having salinity of 7070 mg/l (the date of test is not given in the database). Other holes within the area of the anomaly also have high salinities, but have intersected the Quaternary aquifer only. Hence there appears to be a pocket of high salinity water within the Tertiary aquifer beneath this part of the plain. Careful examination of the DEM shows that this area is in the zone of low dunes north of the River Angas, which would not be inundated during even major floods (see Figure 65). Hence a preliminary conclusion is made that lack of recharge in this area has allowed build-up of salt in the Quaternary sediment, with this passing down into the Tertiary. The elongate shape of the anomaly may reflect the groundwater flow direction. The anomaly appears to extend northwest to the sediment/basement contact, and there is also a possibility that the anomaly is due to saline water from the fractured rock aquifer in basement leaking into the sediment from a conduit.

It is possible that there is recharge to an aquifer in the interpreted zone of Tertiary sediment northwest of the Sandergrove Fault from the Angas River (see Section 6.1.3 and Figure 27). There is a nick point where the river crosses basement rock bars immediately southeast of the interpreted fault location (Figure 69), and it is expected that the bars may pond the river at very low flow, resulting in continuous saturation of the sediment below the river over the interpreted location of Tertiary sediment.

Figure 69. Basement exposure forming a nick point in the bed of the Angas River at ~ 310600 6093900, looking southwest. The rise in the background (locality E in Figure 44) is interpreted to be made up of poorly consolidated Tertiary sediments rather than basement as there is calcrete in the soil. However, there are no apparent outcrops to confirm this interpretation. The shallow basement in this area is interpreted to be on the up thrown side of the Sandergrove Fault.

7.9.5 Surface hydrology

Surface waters on the alluvial plain can be attributed to either local runoff/accumulation from rainfall, and water introduced to the area by the Angas and Bremer Rivers. Flow in the rivers is seasonal, with flow to the lake generally only occurring in winter or after heavy rain. Local landowners believe that flow in the rivers has recently been reduced by increased numbers of farm dams in the catchment area trapping runoff that otherwise would reach the alluvial plain. However it is possible that aboriginal burning off, and European clearing in the 19th and 20th Centuries increased runoff from what it would have naturally been without anthropogenic influences. Floodwaters on the alluvial plains have previously been used to flood irrigate vineyards, and a series of levees and water gates have been constructed to control the flow of floodwater. The lower Angas River terminated in swamps prior to excavation of a channel to Lake Alexandrina following settlement.

It is considered probable that the areas of sediment with highest radioelement content represent the areas that were subjected to flooding prior to anthropogenic interference with the alluvial system, and deep incision of the Angas River (possibly a result of clearing of the catchment).

7.10 Lake Alexandrina

Lake Alexandrina is part of the estuary of the River Murray. It is a large (~600 km^2) shallow (mostly 2.5-4 m deep) body of water kept fresh by a barrier dune complex and man-made barrages that stop ingress of seawater.

7.10.1 Sediments

Investigations by E.J. Barnett (1993, 1994) suggests that Holocene lake-floor sediments are 4-5 m thick; these are referred to the St Kilda Formation. The sediments are muddy, becoming sandier closer to where the Murray enters the lake (C. von der Borch, Flinders University, pers. comm. 2003). Long term deposition rates are about 0.5 mm/year, but modern radiocarbon dates were obtained down to 129 cm in one core, suggesting a recent acceleration in sedimentation rate. According to E.J. Barnett (1994) these sediments overlie Pleistocene siliceous and calcareous sediments of the Coomandook and Padthaway Formations. This interpretation is not supported by Brown & Stephenson (1991) It is expected that as sea level rose and fell with glaciations in the Pleistocene, the area would have been alternately inundated and exposed, possibly leading to deposition of alternating estuarine (or even marine, depending on local palaeogeography) and alluvial/swamp deposits during the Pleistocene, leading to interfingering of various sedimentary facies. The Tertiary limestone and associated clastic sediment sequence continues at depth beneath the lake (Brown & Stephenson 1991).

7.10.2 Hydrogeology

Several reports on the hydrogeology of the area report springs in the lake floor (eg Howles 1994, 1995). It is possible that these represent discharge zones from the sub-artesian Tertiary aquifer through zones of higher permeability in the overlying Quaternary sediment. The AEM data show areas of contrasting conductivity at depth within the area (e.g. from ~65 up to ~360 mS/m at 45-50 m), shown in Figure 70. This most probably reflects changes in the salinity of the water within the Tertiary aquifer rather than changes in porosity. It is possible that the distribution of conductivity relates to the locations of discharge zones and water flow paths to these.

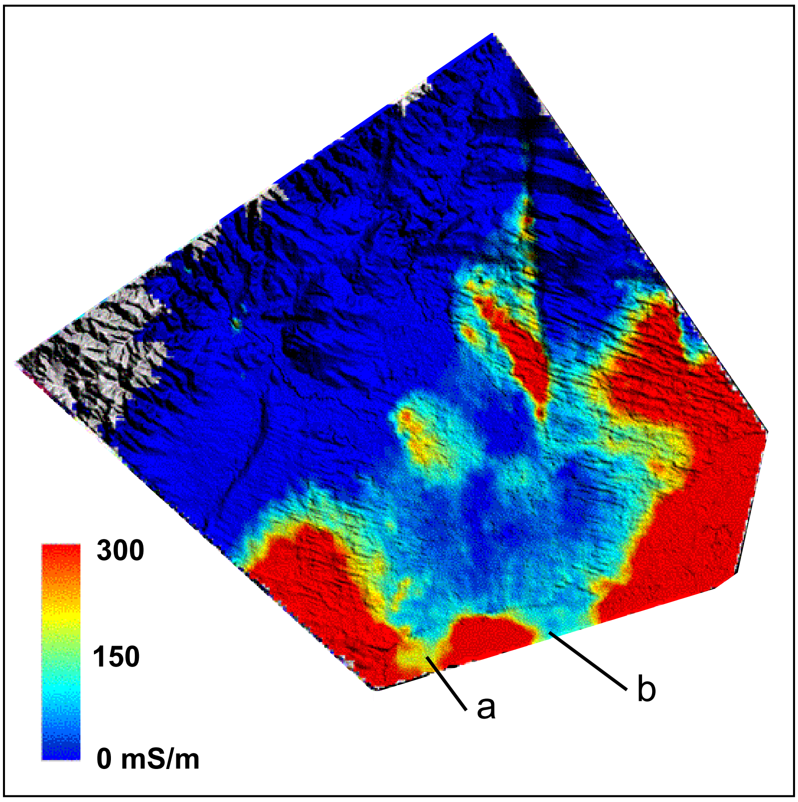


Figure 70. AEM CDI elevation slice for 45 to 50 m below sea level, 0-300 mS/m linear stretch over greyscale DEM with illumination from the northeast, showing contrasts in conductivity within the Tertiary aquifer. The two resistive areas beneath Lake Alexandrina (a and b) may relate to water movement pathways from the north to discharge zones (springs) in the lake floor.

The locations of the discharge zones may be important in the modelling of the groundwater systems. They could possibly be determined using towed array aquatic AEM systems, or thermal satellite imagery. A resistive anomaly at 15-20 m depth immediately offshore from the mouth of the Bremer River (see Figure 68) could represent a zone with fresh water passing up from the limestone aquifer below to springs in the lake floor, possibly through sands deposited at the mouth of the river. The flow of the springs will be dictated by the potentiometric surface in the Tertiary aquifer and the level of the lake. It should be noted that the level of the water in Lake Alexandrina is kept about 75 cm above sea level by a series of artificial barrages (http://www.mdbc.gov.au/river_murray/river_murray_system/barrages/barrage_design.htm March 2004), which also stop the entry of salt water into the lake and lower Murray River. This artificially high water level may well have had an effect on the discharge rate of springs. The level of the lake fell during 2002-2003 as a result of evaporation and water use during a drought, possibly changing the discharge dynamics.

Extraction of large amounts of groundwater in the late 1970's and mid 1980's resulted in drawdown of the potentiometric surface of the Tertiary aquifer, and recharge from the lake (Howles 1995; Telfer et al. 2000). It is possible that the springs flowed in reverse during this time, transferring water from the lake to the aquifer.

The area of the lake became dry land during the last interglacial, changing groundwater flow dynamics and possibly resulting in lowered potentiometric surface. Recharge of saline water may have occurred when sea level rose to modern levels, around 6-7000 years ago (e.g. Williams et al. 1998; Drexel & Preiss 1995; E.J. Barnett 1993, 1994). Prior to this, sea levels had been depressed for 70 000 years or more. There are interpretations that sea levels in the Murray River area reached 3-7 m higher than today since 6000 years ago (e.g. discussion in Brown & Stephenson, p 286; also http://users.esc.net.au/~pereilly/geol_rv.htm March 2004), which might have greatly changed groundwater dynamics in the area. However specific studies of Lake Alexandrina indicate "a maximum sea level of ~ 1 m above present sea level ~6500 years ago" (Drexel & Preiss 1995), not greatly different from modern barrage-induced lake levels.

8. SUMMARY AND CONCLUSIONS

The Angas-Bremer Plains area has a complex late Cenozoic history, which includes deposition during several marine transgressions, periods of uplift/tilting and erosion, faulting, terrestrial deposition, and weathering. The distribution of aquifers, their hydrological properties and the relationships between these materials is a result of this history. Specific conclusions of this study are listed below in several groupings.

8.1 Existing data

- Geological maps of the area (fieldwork carried out in the 1950's) depict surficial materials in several ways, and are not edge matched. In some areas there is little correspondence between patterns of radioelement response (which reflect the nature of materials at the surface) and the maps. One of the major papers describing the geology of the area (including descriptions of individual outcrops) is in French, making reference difficult. Cenozoic age materials are not well represented on the maps. Locations of observation points described in the literature are often not well recorded, making re-examination difficult.
- There are numerous drill holes in the area, mostly water bores, but also mineral exploration holes. The naming of drill holes is confusing, with several types of names being given to holes. To help overcome this difficulty, lists of synonyms are given in Appendix 1. There are problems in referring between the state numbering system used in the 1970's and the current system.
- Many drill holes within the area have brief interpretations of geology available on SA government websites. However there are more detailed logs kept at SA government departments, either as water bore logs or in company reports available on microfiche. Driller's logs for many holes are kept on microfiche at DLWBC, Adelaide.
- The stratigraphy and age of Tertiary age deposits in the area is reasonably well constrained by palaeontological studies. The deposits include late Eocene to Oligocene marine clastic sediments, Oligocene to Miocene limestone (calcarenite) and clastic sediment, Pliocene thick shoreline dune sands and thin seaward equivalent sands. Thin Pliocene sands appear to have been mostly included as part of the "Quaternary" sequence in geological data available from SA Government websites for many holes.
- Onshore Quaternary age deposits in the area have not been dated apart from one radiocarbon date from Holocene alluvium. They are mostly oxidised, and not suitable for preservation of microfossils for dating, apart from sediments on the floor of and adjacent to Lake Alexandrina. They include ?Early Quaternary outwash sediments, alluvium and local swamp/lacustrine sediments deposited up to the present day, and Holocene lacustrine deposits in Lake Alexandrina. A veneer of windblown sand, much of it organised in longitudinal dunes, covers much of the area. Many soils formed on Cenozoic sediments are characterised by the accumulation of regolith carbonate.
- The use of stratigraphic names such as Blanchetown Clay, Chowilla Sand, and Norwest Bend Formation in the area are not warranted.
- The geological history of the area includes Cenozoic deposition, faulting, tilting associated with uplift, and erosion. The lack of dates for Quaternary sediments makes accurate interpretation of history difficult.
- There have been several hydrogeological studies of the Angas-Bremer irrigation area, but little work has been done on the remainder of the study area. These studies have resulted in conceptual understanding of the hydrogeology of the Angas-Bremer alluvial plain, with some modelling carried out. Shallow saline aquifers in Quaternary sediments are separated from a sub-artesian aquifer in Tertiary limestone and associated sediments with variable water quality (mostly fresh beneath the alluvial plain, but saline elsewhere) by a leaky aquitard. However, the hydrogeology of the surrounding areas is not well known.
- The Angas-Bremer observation well network available from the DLWBC website provides details of water table, salinity, well construction, elevation and location for several hundred observation wells in the area.

- Geophysical studies from the 1960s resulted in the model of a faulted hydrogeological basin margin in the area. This fault was thought to control much of the recharge to the semi-confined aquifer. There is no evidence for this proposed fault in new geophysical coverages.
- 1:50 000 scale soil maps have been prepared over the area from observations in auger holes, soil pits and photointerpretation. Data from auger holes are kept by SA Government departments.

8.2 Interpretation of New Geophysics.

- New DEMs of the area are accurate to several metres elevation and show many details of topography. Errors in the DEMs can be attributed to several sources.
- AEM data, expressed as CDI depth and elevation slices processed to 200 m depth, and flight line sections, show great variability in conductivity (0->1000 mS/m).
- There is broad correlation between groundwater salinity and AEM conductivity. However, the relationship is not good enough to be able to use conductivity to accurately delineate areas with high quality groundwater in the Tertiary aquifer.
- The AEM data suggest that previously unknown areas of low salinity groundwater may be present in the Tertiary aquifer in an area of low hills north of the Angas Bremer alluvial plain.
- CDI conductivity slices show the likely extent of a previously poorly documented high salinity zone within the Tertiary aquifer beneath part of the Angas Bremer alluvial plain.
- AEM conductivity data alone cannot be used to determine the depth to basement beneath Murray Basin sediment as the AEM conductivity at the contact in drill holes varies markedly.
- Basement structure contours beneath Murray Basin sediments were estimated by combining drill hole and conductivity data. The Quaternary/Tertiary contact could not be accurately recognised from conductivity data, but the geometry of the contact can be determined from data from hundreds of drill holes.
- The three main areas of shallow AEM conductive anomalies can be related to either clay-rich sediment at the surface or areas with very shallow saline water table.
- Magnetic coverages suggest the presence of large and small buried magnetic intrusions. Drill hole data suggests that these may be granite and ultramafic rocks which have intruded the Cambrian metasediments which comprise outcropping basement in the area.
- Magnetic data show limited high frequency signatures resulting from detrital magnetic minerals, and no palaeochannels in the main alluvial plain area are evident. Linear trends in magnetic response are present in areas of Pliocene dunes, parallel to the dunes, possibly representing concentrations of heavy minerals.
- Radiometric coverages show great variation in radioelement concentration. K, Th and U responses all have positive correlations with each other, and single channel or total count responses can be used as a surrogate for overall response over much of the area. However some subtle variations show on ternary plots due to slightly different proportions of radioelements. The radiometrics appear to have the potential to be a very useful tool for enhanced soil mapping.
- Ground EM surveys show many features imaged by the AEM. The ground survey data have not been processed to take into account conductivity profiles from drill holes along the lines, so their usefulness is currently limited.

8.3 Structure of Cenozoic sediments

- Three north-trending faults have displaced the Cenozoic sediments, west side down. These show as linear features in the landscape, and discontinuities in AEM data.
- The previously undescribed Sandergrove Fault has had movement spanning several stages of Cenozoic sedimentation. Basement subcrops beneath thin cover in a fault scarp on its eastern side. It defines the eastern edge of a previously undescribed small groundwater basin, and passes close to Strathalbyn. Movements have affected drainage in the area: the River Angas has eroded an antecedent gorge across the eastern upthrown side of the fault, and Sandergrove Creek occupies the fault angle depression.

- The Bremer Fault is well known to the north of the area, and is shown to extend well into the area by AEM and drill hole data. It offsets the Cenozoic sequence by up to 80 m.
- A third previously undescribed fault east of and parallel to the Bremer Fault extends a short distance into the area.
- A fault postulated from geophysical soundings in the 1960s does not have any signature in the new geophysical coverages, and variations in basement elevation in drill holes around the area of the proposed fault can be ascribed to tilting, or possibly pre-sedimentation palaeo topography.
- Structure contours of the base of the Cenozoic sequence have been constructed from interpretation of AEM and drill hole data.

8.4 Specific features interpreted from geophysics and drill data

- The area has been subdivided into ten units with relatively uniform landscape geology and regolith. These could form the basis for future delineation of natural resource management units.
- Cappings of deeply weathered basement and small outliers of Tertiary sediment in the eastern Mt Lofty Ranges are imaged by radiometrics and AEM. Some of these have not been previously mapped. These areas of thicker regolith may contain salt stores.
- Alluvium along the Bremer River to the north of the main Angas-Bremer alluvial plain appears to be preserved in a downwarped area. This is in contact with the Tertiary limestone aquifer, and river water may be charging the aquifer via the alluvium in this area.
- The low relief area between Sandergrove Creek and basement hills to the west consists of pediments and rises over basement rocks and ?Early Quaternary sediments, and coalesced low angle fans. Tertiary limestone with brackish to saline water is present in a small groundwater basin created by movements along the Sandergrove Fault. Recharge may be partly from the Angas River.
- Hills east of Strathalbyn have a sandy cover that originates from locally iron-cemented Tertiary estuarine to marine sands with minor silt and gravel up to 10s of metres thick. Tertiary limestone crops out in the southwest of the area. Some of the sand has been reworked into Quaternary longitudinal dunes and sand sheets. Salt may be stored in the regolith in this area, and the sandy regolith may allow rapid deep drainage.
- The Milang dunefield between Sandergrove Creek and the Angas-Bremer alluvial plain has formed on a gently tilted fault block which no longer receives sediment from the ranges to the west. Aeolian sand overlies 15-20 m of clayey ?Early Quaternary sediment, over Tertiary limestone and associated sediments that are absent in the far west of the area and thicken to the east. The limestone is above water table in the west but is saturated with sub artesian saline water in the central and east part of the area. An area devoid of sand cover is interpreted as a deflation feature, and has very high surface conductivity due to exposure of clay with high saline moisture content.
- Hills east of the Bremer River in the northern part of the area include relict Pliocene barrier dunes with a maximum sand thickness of >50 m. These may allow rapid deep drainage to the Tertiary aquifer. In other parts of this area, clastic clayey to gravelly sediments of unknown age overlie Tertiary limestone, which has variable conductivity and may contain areas of relatively low salinity groundwater. Areas of internal drainage west of the Bremer Fault result from downwarp against the fault.
- Dunefields east of the Angas-Bremer alluvial plain are locally of lower elevation than the alluvial plain. Source bordering dunes have prevented eastward migration of the Bremer River into these lower elevation areas. The limestone aquifer at depth beneath the dunefields in the north has high conductivity due to saline water, but conductivity is lower in the area south of Mosquito Creek due to presence of less saline water.
- Sediment carried to Lake Alexandrina by the Bremer River is interpreted to have been transported eastward by wind driven currents and waves to form a lobate marshy shoreline. Conductivity in this area is mostly high, and there is extremely saline water in shallow

aquifers as well as in the underlying Tertiary aquifer. The high salinity probably results from evaporation, but ingress of salt water from previous times of high lake salinity is also possible.

- The Angas-Bremer alluvial plain results from deposition of alluvial and swamp deposits, with superimposed aeolian deposits derived from the Milang dunefield to the west and the rivers themselves. Details of the gradient and irregularities of the plain surface are shown by the new DEMs. The Angas River has a steeper gradient, and has deposited a low lobe of sediment where it enters the main plain. The channels of the Angas and Bremer Rivers are fixed. If this style of channel has existed in the geological past, it means that channel sand deposits are likely to have low width to thickness ratios.
- Much of the Quaternary alluvial sediment is below modern sea level, implying that either it was deposited at times of lower sea level, or there has been downwarp of the area. Possible stages in sedimentation probably relate to several factors, including climate, vegetation, sea level and tectonics.
- AEM conductivity shows zones of lowest conductivity in shallow sediments along the courses of the rivers, suggesting groundwater recharge throughout the area along the rivers, not concentrated where the rivers cross an interpreted fault as has been previously suggested.
- The limestone aquifer beneath the alluvial plain has mostly fresh to slightly brackish water. However an area of high conductivity associated with more saline water is present at the northwest margin of the plain north of the Angas River. This may either relate to lack of recharge/flushing in an area of source bordering dunes, or introduction of saline water into the aquifer from a basement conduit.
- Conductivity of the Cenozoic sediments beneath Lake Alexandrina is variable, possibly due to varying salinity associated with groundwater flow paths to discharge springs on the lake floor.

9. SUGGESTIONS FOR FURTHER WORK

This study has highlighted many areas that could be investigated to allow a more detailed interpretation of the 3D earth materials distribution of the area, and to allow more detailed hydrogeological modelling. Possible specific further work includes:

- Obtain more deep induction conductivity geophysical logs to allow better constrained inversion of the AEM data. Induction logs must be taken in plastic or uncased holes. There are very few of these available, and new drilling may be required. Better inversion of the AEM data could allow better prediction of groundwater salinity and depth to basement. It might be necessary to treat the data from areas with saline groundwater and high conductivities differently from areas with low salinity groundwater.
- Determine whether basement depth can be estimated from features of AEM conductivity profiles such as inflexion points, rather than trying to use a conductivity cut-off value to estimate basement, and use any success to better constrain the geometry of the base of the sedimentary section.
- Determine whether reprocessed AEM data can be used to predict the location of the top of the Tertiary aquifer. This might be useful for modelling the Tertiary/Quaternary contact in areas with few drill holes.
- Construct a 3D GIS showing DEM, base of the Quaternary and Tertiary aquifers, geophysical data, water table etc. This would be of use in hydrogeological modelling.
- Investigate the possibility of recharge from rainfall directly to the Tertiary aquifer in areas where it is close to the surface or where it is covered by Pliocene sands.
- Increase the knowledge of water salinity and water table/potentiometric surface throughout the study area, to allow modelling of the aquifer systems away from the alluvial plain.
- Investigate the relationship between AEM conductivity and water salinity within the Quaternary aquifer, using existing observation well and possibly new targeted water bore data. This could allow better modelling of the salinity of the Quaternary unconfined aquifer.
- Investigate the relationship between soil types, microrelief as shown by the DEMs, and radiometric responses. This study could possibly include supervised classification of the area into polygons based on radiometric response, and soil sampling within the polygons. Use the knowledge gained to generate new soils/land management maps.
- Investigate outliers of Tertiary sediment (including the hills east of Strathalbyn) and cappings of highly weathered bedrock in the Mt Lofty Ranges to determine lithology, age, and potential for salt storage and recharge.
- Investigate sediments across the area of low hills east of Strathalbyn and rises north of Strathalbyn to determine their age, geometry, hydrogeological properties and potential for salt storage.
- Investigate discharge springs in Lake Alexandrina, and their relationship to resistive zones in the AEM data, to help determine water flow lines. Springs could possibly be detected by towed floating AEM array or thermal imaging.

Other possible studies include

- Investigate the Sandergrove and Bremer Faults and the sediments they have displaced to determine timing of last movement to help determine earthquake risk for the area.
- Investigate depth of water during deposition of Tertiary sediments by sedimentary facies and fossil types, to determine whether high level outliers have been tilted and raised compared with low elevation deposits, or whether the outliers represent shallow water facies equivalents of deeper water deposits, that have not been tectonically affected.

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APPENDIX 1

DRILL HOLES USED IN THIS STUDY, WITH ALTERNATIVE NAMES

This is a comprehensive listing of all drill holes used in this study, arranged in several ways to facilitate easy reference to several types of identification names:

1. Listing by sequential id number
2. Listing by obswell name
3. Listing by other names

These tables should allow any synonyms of holes and locations to be rapidly found.

All holes except project holes from this study have a unique identification number (id), based on the 1:100 000 sheet number (6627 – Milang; 6727 - Mobilong) followed by a sequential number of up to 5 digits. In this report a dash is used between the two parts of the id (eg 6627-8149). This hole may also be represented as 66278149 or 662708149.

Holes in the Angas Bremer observation well network are also known by names based on an abbreviation of the local ‘hundred’ name (BRM-Bremer; FRL-Freeling; STY-Strathalbyn) followed with a sequential number. In many cases suffixes below 100 refer to wells finished in Quaternary aquifers, and suffixes above 100 refer to those finished in the Tertiary aquifer. In some cases a single hole is apparently known by two names. However, in these cases, only one name was shown on the DWLBC website in February, 2004. The other name, marked with ** in the tables below, was given as an alternative name in earlier data, and appears to be not now in use.

Other names for holes include company and government names. The prefix DM refers to SA Dept of Mines stratigraphic holes, labelled DM followed by sequential numbers.

The author does not have a listing of an earlier state-wide system of hole names, consisting of 9 digits in the form 360-3606-03, with numbers referring to the “hundred” (360), “section (3606) and hole number in that section. The numbers were at times not separated by dashes (360360603), or abbreviated by leaving off the hundred number (360603). Various reports on the hydrogeology of the area published in the 1970’s use this numbering system. Where it has been possible to identify the bores, by location or if a DM number is also given, this number is also given in the tables. Note that DM1 (6727-1527) is shown both as 360-3606-01 and 360-3580-01 by Bowden & Bleys (1971) (the latter is an obvious drafting error), but also as 360-3606-03 by Waterhouse and Gerges (1979). Figure 7 of Carosone and Cobb (1975) shows DM1 as 360603, and shows 360-3606-01 to be hole 6727-1525 (FRL50). Therefore it appears that both numbers given by Bowden & Bleys (1971) for DM1 are in error.

Locations are given as metric grid references, according to the GDA 94 datum. In some cases, locations of holes as given in the SA databases in February 2004 have been updated from earlier designated locations. Where this has happened, the location eastings and northings have been marked with * to show that they are the latest figures available.

Hole id	Names	Easting	Northing
6627-747		316287	6079758
6627-775		316503	6080293
6627-776	BRM 35	316666	6080404
6627-777	BRM 233	316666	6080404
6627-781		314822	6080380
6627-788	BRM 186	307433	6081826
6627-860		309032	6089282
6627-864	BRM 38, DM16	312114	6086970
6627-868		314176	6087221
6627-870	BRM 230	315122	6086596
6627-872	BRM 111	316557	6087684
6627-874		315978	6086922
6627-875	BRM 115	316224	6086435
6627-885	BRM 116	318105	6086525
6627-889	BRM 114	318129	6087222
6627-891		317382	6087175
6627-892		316894	6087667
6627-893	BRM 166	317139	6087725
6627-894	BRM 112	317018	6087435
6627-895	BRM 13	317146	6087397
6627-899	BRM 110	316789	6087933
6627-900	BRM 12	317165	6087910
6627-906		317894	6089996
6627-908	BRM 6	318008	6090726
6627-914		316725	6091308
6627-915		316155	6092091
6627-917	BRM 234	315527	6092061
6627-919	DM19	316070	6090840
6627-922	DM13	316965	6090351
6627-929		317014	6090285
6627-932		316028	6089614
6627-934		315321	6088554
6627-935	BRM 236	315841	6088993
6627-936		315321	6088554
6627-937		315149	6089292
6627-944		314627	6089266
6627-948	BRM 211	315382	6090967
6627-953	DM17	315387	6091332
6627-961	DM18	314278	6091947
6627-968		313088	6090285
6627-973	DM21	313607	6092463
6627-983		311805	6090929
6627-1001		307072	6091315
6627-1013		307598	6092316
6627-1128	STRATH SILO 1	308650	6096244
6627-1141		312254	6096521
6627-1145		313302	6096993
6627-1147		313691	6097024
6627-1151		314318	6094360

Hole id	Names	Easting	Northing
6627-1152		314243	6094368
6627-1158		314769	6096314
6627-1165		317666	6097332
6627-1167	STY 201	317685	6096504
6627-1170	DM23	317842	6096724
6627-1177	STY 10, DM27	317511	6094635
6627-1180	STY 204	316855	6093807
6627-1181	STY 4	316906	6093095
6627-1182	STY 6	316795	6092272
6627-1184	DM22	317385	6091711
6627-1186	STY 203	318102	6093498
6627-1196		317081	6080901
6627-1199	BRM 228	318181	6081161
6627-1204	BRM 145	315965	6081542
6627-1206		316243	6081907
6627-1207		316603	6082041
6627-1212	BRM 148	317610	6082253
6627-1213	BRM 144	317444	6082172
6627-1214		317199	6081896
6627-1218	BRM 139	317575	6083467
6627-1220	BRM 138	316944	6083106
6627-1221		317704	6083135
6627-1223	BRM 221	317189	6082972
6627-1224	BRM 33	317189	6082972
6627-1225	BRM 133	317105	6084168
6627-1228	BRM 125	318007	6084353
6627-1237	BRM 218	318143	6084599
6627-1241		317767	6085972
6627-1242		317456	6085748
6627-1244	BRM 124	317893	6085398
6627-1245	BRM 164	317781	6086190
6627-1246	BRM 165	317830	6086179
6627-1247		318110	6086455
6627-1248	BRM 34	317581*	6086050*
6627-1249	BRM 232	317817	6086239
6627-1250		317154	6086113
6627-1251	BRM 20	316623	6085515
6627-1252	BRM 120	316947	6086221
6627-1253	BRM 30, DM12	316599	6084640
6627-1254	BRM 217	316599	6084640
6627-1255		316043	6085997
6627-1256	BRM 119	316043	6085820
6627-1257		316043	6086107
6627-1258		315921	6085811
6627-1260		315643	6085404
6627-1265	BRM 21, BRM 123**	316304	6084741
6627-1267		315942	6084893
6627-1273	BRM 19	314801	6085002
6627-1277		316519	6084414
6627-1278		316241	6084483

Hole id	Names	Easting	Northing
6627-1282	BRM 132	316361	6084111
6627-1283		316448	6083046
6627-1289		316137	6082699
6627-1290	BRM 32, BRM 142**	316376	6082747
6627-1291		316030	6082568
6627-1292		316234	6082756
6627-1294		316232	6082392
6627-1296		315292	6081808
6627-1297		315401	6081320
6627-1298		315538	6081382
6627-1299		315466	6081560
6627-1301		315331	6080944
6627-1314		313716	6082940
6627-1315	BRM 5	313513	6082922
6627-1317		312897	6081505
6627-1318		312814	6081501
6627-1320		314017	6081735
6627-1321		313935	6081575
6627-1322		314208	6081625
6627-1324		314466	6082003
6627-1325		314255	6082999
6627-1326		314577	6082866
6627-1327		314801	6082554
6627-1328		314846	6082611
6627-1329	BRM 235	315029	6083099
6627-1330		314707	6083446
6627-1332		314032	6083480
6627-1335	BRM 231	313992	6084831
6627-1336	BRM 18	314356	6085377
6627-1337		314448	6085373
6627-1340		312594	6086335
6627-1957		317072	6084581
6627-1958		317446	6084435
6627-5774		311659	6097668
6627-5792		312761*	6099968*
6627-5795		314113	6099262
6627-5808		310978	6100619
6627-5996		317947	6097339
6627-6003		317314	6091585
6627-6047		318114	6086474
6627-6051		310850	6101613
6627-6341	BRM 161	317211	6087072
6627-6383	BRM 163	316466	6085993
6627-6543		310752	6102042
6627-6546		311725	6100415
6627-6628		305512	6091227
6627-6692		317902	6096646
6627-6781	STY 115**, STY 12**	318049	6096400
6627-6783		317740	6097479
6627-6792		316812	6087608

Hole id	Names	Easting	Northing
6627-6837		304956	6087510
6627-6838		305203	6086091
6627-6841		305877	6091037
6627-6855	BRM 162**	317040	6084099
6627-6979		308661	6091383
6627-7089		309176	6090163
6627-7180	STY 111	317435	6092289
6627-7198	BRM 156	312840	6084681
6627-7199	BRM 160	312870	6084683
6627-7206		311596	6088006
6627-7235		308636	6093864
6627-7264	BRM 157	315900	6081499
6627-7388		36255	6093715
6627-7439		316058	6094084
6627-7445		315434	6092552
6627-7446		315499	6092444
6627-7447		316145	6092256
6627-7659		315486	6094108
6627-7742		317236	6087194
6627-7743		316513	6085795
6627-7760		316185	6096622
6627-7829	BRM 180	315560	6089380
6627-7889		316083	6090991
6627-8039		315162	6089258
6627-8147	81MBR 70	315522	6095078
6627-8148	81MBR 71	309307	6082578
6627-8149	81MBR 72	310922	6080478
6627-8157		317672	6097468
6627-8161	82MB12RM 1	312442	6093358
6627-8253		317652	6083448
6627-8268		315347	6091148
6627-8272		306353	6090821
6627-8279		312300	6101235
6627-8284		316887	6098273
6627-8317	BRM 238	307433	6081826
6627-8618	BRM 239	315857	6081463
6627-8619	BRM 246	312822	6085028
6627-8620	STY 207	317437	6092308
6627-8654		305563	6088152
6627-8655		317652	6087793
6627-8696		316312	6091948
6627-8765	BRM 248	317581	6086050
6627-8766	BRM 249	316652	6084633
6627-8767	BRM 250	315562	6089363
6627-8889		315166	6100643
6627-8890		314646	6101028
6627-8953	PD85HA 1	313127	6096353
6627-9017	81WCP 1	314112	6104423
6627-9018	81RVP 1	309972	6101626
6627-9019	81WCP 2	314167	6104628

Hole id	Names	Easting	Northing
6627-9133	STRATH BRIDGE 1	308197	6096903
6627-9134	STRATH BRIDGE 6	308072	6096838
6627-9135	STRATH BRIDGE 13	308127	6096863
6627-9167		312216	6086618
6627-9168		312241	6086748
6627-9169		312256	6086538
6627-9170	BRM 183	315112	6086638
6627-9627		316911	6097888
6627-10022		315271	6089838
6627-10626		304483	6084859
6627-10635		306641	6088992
6627-10683		314902	6101545
6627-10726		306364	6089440
6727-276	BREMER G	320402	6109703
6727-539	MC 56	321144	6104824
6727-541	MC 96	326113	6107380
6727-659	BREMER E	320409	6109737
6727-723	MC 87	322172	6109744
6727-724	MC 88	322316	6110037
6727-1257		323203	6084473
6727-1290	FRL 146, P.95863	322955	6090759
6727-1381		324567	6102608
6727-1401	FRL 75	322032	6092298
6727-1405		319643	6100201
6727-1412	BRM 181	320285	6089605
6727-1415	MC 92	325872	6101283
6727-1433		327662	6094860
6727-1435	FRL 205	328210	6092728
6727-1442	FRL 23	330362	6091808
6727-1445		331827	6091870
6727-1451		329188	6095701
6727-1453	FRL 116	328673	6090616
6727-1455	FRL 26	328653	6090537
6727-1456		328343	6090504
6727-1457	FRL 117	329295	6090600
6727-1458		321885	6106853
6727-1459	FRL 206	330573	6091258
6727-1460	FRL 38	327888*	6089284*
6727-1462		328113	6090175
6727-1463		328146	6089914
6727-1464		327954	6090130
6727-1465	FRL 119	328715	6089792
6727-1466	FRL 28	328481	6089901
6727-1468	FRL 43	329361	6088692
6727-1470	FRL 66, DM11	329003	6090292
6727-1476	FRL 226	328721	6090308
6727-1477	FRL 29	329257	6090238
6727-1478	FRL 30	330196	6089856
6727-1479	FRL 27	331316	6090686
6727-1480	FRL 118	331591	6090339

Hole id	Names	Easting	Northing
6727-1482		331491	6089264
6727-1484	FRL 47	327492	6087190
6727-1486		327906	6087432
6727-1488	FRL 44	328656	6088649
6727-1489	FRL 45	328568	6087965
6727-1490	FRL 46, FRL 127**	328923	6087523
6727-1491	FRL 74	328746	6087607
6727-1492	FRL 212	328421	6087777
6727-1493		328364	6086668
6727-1494		329064	6087238
6727-1495	FRL 55	329024	6086384
6727-1497		327961	6086095
6727-1498		325119	6090453
6727-1499	FRL 54	327587	6085610
6727-1501		327864	6085276
6727-1502		328678	6085325
6727-1504	FRL 209	328261	6085276
6727-1505	FRL 67, DM15	329296	6085757
6727-1506	FRL 228	329296	6085757
6727-1507		329952	6086009
6727-1508	FRL 56	329146	6084816
6727-1509	FRL 57	327684	6084281
6727-1511		328953	6083634
6727-1514	FRL 159	329999	6087990
6727-1517	FRL 220	323233	6082116
6727-1518		323605	6082312
6727-1519	FRL 136	323501	6082978
6727-1520	FRL 137	323126	6083052
6727-1521		323122	6082934
6727-1522	FRL 60	323277	6083529
6727-1525	FRL 50, 360-3606-01	323933	6084833
6727-1527	FRL 52, DM1, Langhorne Creek No 1, 360-3606-03	323227	6084473
6727-1528	FRL 51, DM2, 360-3606-05	322936	6084482
6727-1529	DM3, 360-3606-04	323015	6084508
6727-1531	FRL 217	323227	6084473
6727-1532	FRL 130	323566	6084927
6727-1533	FRL 145	323074	6085179
6727-1535		323473	6085367
6727-1538	FRL 49	323828	6085815
6727-1539	FRL 128	322989	6086065
6727-1542		323828	6085815
6727-1544	FRL 147	322753	6086364
6727-1545	FRL 215	324713	6085968
6727-1548	FRL 53	327221	6085478
6727-1550		327185	6084388
6727-1552	FRL 218	326791	6084355
6727-1559		324101	6083741
6727-1560		324918	6083660
6727-1561		325037	6083629
6727-1562		325200	6083699

Hole id	Names	Easting	Northing
6727-1563	FRL 135	325062	6084015
6727-1564	FRL 219	324744	6083614
6727-1565		324799	6083451
6727-1566		324438	6082777
6727-1567	FRL 61	324166	6082351
6727-1568		324170	6082550
6727-1570	FRL 65	324326*	6082288*
6727-1575	FRL 131	325919	6084939
6727-1576	FRL 133	325769	6084574
6727-1579	FRL 58	326552	6083517
6727-1580	FRL 59	325649	6083317
6727-1581		325984	6082917
6727-1582		325847	6082944
6727-1585	FRL 221	326571	6082640
6727-1588		326430	6084765
6727-1589	FRL 132	326506	6084619
6727-1591		326272	6084416
6727-1592		326436	6084502
6727-1593		319961	6081548
6727-1594	BRM 227	319762	6081518
6727-1595	BRM 226	320969	6081860
6727-1596	BRM 223	321540	6081963
6727-1597	BRM 229	322713	6082115
6727-1599		322521	6083225
6727-1600	BRM 28	322036	6082235
6727-1602		321957	6082228
6727-1603		321689	6082056
6727-1604	BRM 147	321440	6082111
6727-1605	BRM 27	320832	6082839
6727-1606	BRM 37	320431	6081798
6727-1607	BRM 222	320431	6081798
6727-1610	BRM 36	318773	6081365
6727-1611	BRM 224	318782	6081974
6727-1612	BRM 29	318625	6081825
6727-1613	BRM 31	318855	6082773
6727-1614	BRM 143	319258	6082604
6727-1615	BRM 140	318458	6083407
6727-1617		318490	6083792
6727-1618	BRM 134	318598	6084049
6727-1619	BRM 40	318741	6085187
6727-1621		318721	6085935
6727-1622	BRM 126	318784	6085339
6727-1624		318931	6086392
6727-1625		319120	6085923
6727-1626		318941	6085699
6727-1627	BRM 127	319323	6085212
6727-1628		319116	6084986
6727-1631	BRM 23, BRM 128	318892	6084631
6727-1633		322538	6106285
6727-1640	BRM 135	319845	6083955

Hole id	Names	Easting	Northing
6727-1642	BRM 24	319024	6084003
6727-1643		319384	6083618
6727-1644	BRM 25	320039	6083258
6727-1647	BRM 17	320902	6086177
6727-1648	BRM 121	321829	6086096
6727-1649	BRM 122	322556	6086116
6727-1650		322484	6085828
6727-1651		322215	6086139
6727-1653		320965	6085187
6727-1654	BRM 129	320691	6084724
6727-1655	FRL 161	322972	6085092
6727-1657	BRM 168	321616	6091850
6727-1658	BRM 216	320527	6085681
6727-1659	BRM 219	321923	6084505
6727-1660	BRM 169	321187	6085159
6727-1661		321985	6085526
6727-1662	BRM 130	322319	6085508
6727-1664	BRM 131	322535	6085044
6727-1667	BRM 137	322785	6084254
6727-1670		323066	6083733
6727-1671	BRM 26, BRM 141**	321240	6083652
6727-1672	BRM 220	320480	6083719
6727-1673	BRM 136	321656	6083906
6727-1676		322427	6091202
6727-1679	FRL 62	322727*	6090915*
6727-1680	FRL 225	322729*	6090916*
6727-1681		322238	6091797
6727-1683		322194	6091840
6727-1686		322578	6091310
6727-1687	FRL 19	322651	6091223
6727-1692	FRL 24	324099	6090347
6727-1693	FRL 63	324237*	6090179*
6727-1694	FRL 224	324238*	6090179*
6727-1695	FRL 112	324238	6090506
6727-1696		324238	6090506
6727-1697	FRL 148	323986	6090510
6727-1698	FRL 35, DM10, 360-3569-01	325790	6089763
6727-1699	FRL 210	325790	6089763
6727-1700		322925	6089977
6727-1701	FRL 207	323221	6089935
6727-1703	FRL 120	322567	6090169
6727-1704	FRL 31	322488	6089759
6727-1705	FRL 32, DM9, 360-3574-01	322870	6089677
6727-1707	FRL 33	322209	6089091
6727-1710		326417	6090398
6727-1712	FRL 122	322902	6088744
6727-1714	FRL 208	322776	6088701
6727-1718	FRL 124	322847	6088163
6727-1723		322727	6088413
6727-1727	FRL 126	322896	6087309

Hole id	Names	Easting	Northing
6727-1728		322920	6087323
6727-1730	FRL 48	323536	6086660
6727-1731		322867	6086869
6727-1736	FRL 64	322545*	6086988*
6727-1737	FRL 216	322545*	6086987*
6727-1738	FRL 39	323640	6087467
6727-1739	FRL 40	324105	6086993
6727-1741	FRL 123	323895	6088712
6727-1742	FRL 125	323627	6088239
6727-1743	FRL 213	324266	6088181
6727-1745		324805	6086829
6727-1747	FRL 34	323761	6089416
6727-1748		324092	6088694
6727-1751	FRL 41	325105	6087986
6727-1753		326096	6087254
6727-1754	FRL 129	326393	6086751
6727-1755	FRL 36, FRL 121**	325624	6089153
6727-1758	FRL 37	326425	6089528
6727-1760		327051	6088655
6727-1761	FRL 42	326929	6088451
6727-1762	FRL 214	326927	6086963
6727-1764	FRL 211	326180	6089044
6727-1766	FRL 111	323094	6091465
6727-1769		326372	6092143
6727-1770		326425	6092084
6727-1771	FRL 21	326557	6091503
6727-1773	FRL 20	324826	6091633
6727-1774		324646	6090453
6727-1777	FRL 113	325160	6090601
6727-1778	FRL 114	325243	6090419
6727-1779		325123	6090417
6727-1781		319539	6090465
6727-1782	FRL 25	325768	6090754
6727-1785	FRL 22	326871	6090869
6727-1787	FRL 115	326878	6090360
6727-1788		327233	6090171
6727-1794	FRL 5	320143	6095181
6727-1795	FRL 201	319915	6095176
6727-1796	FRL 103	320414	6094799
6727-1797	FRL 102, 360-0099-04	319937	6094721
6727-1798	FRL 4, DM7, 360-0099-05	320311	6095799
6727-1799	FRL 2	320080	6096567
6727-1800	FRL 1	320076	6096597
6727-1801		320579	6097090
6727-1802		320395	6096132
6727-1803		320395	6096132
6727-1804	FRL 164	320767	6096077
6727-1805	FRL 101	321207	6095667
6727-1806		320620	6095406
6727-1807	FRL 6	320876	6094860

Hole id	Names	Easting	Northing
6727-1809	FRL 3	321585	6096545
6727-1812		322255	6091728
6727-1814	FRL 104	321788	6095128
6727-1816		322026	6094722
6727-1818	FRL 10	322534	6093922
6727-1820	FRL 13	322821	6093139
6727-1822		323484	6093744
6727-1823		323629	6093288
6727-1824	FRL 222	324144	6093175
6727-1825	FRL 16	323726	6092541
6727-1826	FRL 239	322264	6096851
6727-1831		322873	6095759
6727-1832	FRL 7	322604	6095169
6727-1833	FRL 223	322409	6095475
6727-1836	FRL 9	323582	6094953
6727-1841	FRL 14	325401	6093718
6727-1843	FRL 17	325427	6093118
6727-1844		325425	6093125
6727-1845		324883	6093027
6727-1846	FRL 18	326698	6092534
6727-1847	FRL 227	326674	6093378
6727-1852	FRL 106, FRL 154**	321209	6093489
6727-1853	FRL 8	321603	6094154
6727-1855	FRL 105	321641	6093500
6727-1858		321592	6093267
6727-1859	FRL 108	321845	6092725
6727-1860	FRL 11, DM6	322367	6092736
6727-1861	FRL 12, DM5	322466*	6092763*
6727-1862		322084	6092926
6727-1863	FRL 202	322413	6092760
6727-1864	FRL 68	321137	6092992
6727-1865	FRL 107	321504	6093107
6727-1867	FRL 73, DM4, 360-3555-04	321816	6092544
6727-1871	FRL 203	321772	6092421
6727-1873	FRL 109	322116	6092470
6727-1874		322262	6092192
6727-1876	FRL 204	321982	6092408
6727-1879	FRL 110	322630	6092428
6727-1880	FRL 15	322838	6092274
6727-1881	FRL 134	328471	6085378
6727-1885	DM24	319019	6096286
6727-1886		319116	6096057
6727-1887	STY 202	318617	6094593
6727-1888	STY 9, DM26	318465	6095017
6727-1890	STY 1	319518	6094624
6727-1894	DM25	319272	6095407
6727-1895	STY 2	318746	6094044
6727-1896	STY 8	318992	6093811
6727-1897	STY 103	319028	6094000
6727-1898	STY 105	319029	6093408

Hole id	Names	Easting	Northing
6727-1899		321852	6089518
6727-1900		318952	6093363
6727-1903	STY 106	318642	6092187
6727-1904		319808	6092464
6727-1909	STY 3	319995	6094315
6727-1911	STY 101	319837	6094291
6727-1914	STY 205	320267	6093195
6727-1917	STY 7, STY 107**	320368	6092586
6727-1925		321074	6092874
6727-1954		321038	6092159
6727-1956	BRM 2	320883	6092166
6727-1962		321128	6092394
6727-1964	BRM 3, Langhorne Ck. P.S.	321349	6092227
6727-1969		321991	6091898
6727-1970	BRM 201	321537	6092285
6727-1975	BRM 202	321975	6091755
6727-1980	BRM 103	321167	6091173
6727-1982	BRM 203	321633	6091090
6727-1985	BRM 44	321407	6090780
6727-1987	BRM 101	320658	6091916
6727-1988	BRM 1	319564	6091696
6727-1989	BRM 204	319059	6091825
6727-1991	BRM 102	318775	6091753
6727-1994		318294	6091131
6727-1998	BRM 106	318872	6089503
6727-1999	BRM 207	318337	6089456
6727-2000	BRM 104	319401	6090858
6727-2005	BRM 206	319855	6089455
6727-2006		320156	6090672
6727-2011	BRM 4	320852	6091446
6727-2013	BRM 205	320709	6091063
6727-2014	BRM 105	321158	6090056
6727-2015		321023	6089697
6727-2020	BRM 210	322159	6090095
6727-2022	BRM 8, BRM 107**	319307	6089112
6727-2023		319307	6089112
6727-2025	BRM 9	319766	6088641
6727-2027		319704	6087883
6727-2028	BRM 109	320242	6087903
6727-2029	BRM 10	320231	6087848
6727-2033		319776	6088713
6727-2035	BRM 212	318958	6088022
6727-2036	BRM 170	320242	6087903
6727-2038	BRM 208	321141	6089377
6727-2039		321120	6089262
6727-2043	BRM 108	321109	6089061
6727-2044	BRM 171	321063	6088592
6727-2045	BRM 209	321631	6089671
6727-2059		321915	6089234
6727-2060	BRM 172	322023	6088811

Hole id	Names	Easting	Northing
6727-2066		321058	6087227
6727-2069		320797	6087028
6727-2070	BRM 213	320587	6087743
6727-2071	BRM 11	319029	6087762
6727-2072	BRM 118	319814	6086905
6727-2073	BRM 15, BRM 117**	319816	6086859
6727-2074	BRM 16	319268	6086624
6727-2075		319729	6086748
6727-2077	BRM 215	321731	6086909
6727-2079		318497	6086761
6727-2080		318627	6087737
6727-2081	BRM 214	318880	6086610
6727-2082		322432	6091208
6727-2084	STY 102	320218	6093809
6727-2085	STY 104	320316	6093063
6727-2087	STY 114	321476	6092434
6727-2088	FRL 149, FRL 229**	325072	6090342
6727-2097	BRM 174	320649	6091087
6727-2098		327477	6094841
6727-2099	BRM 175	321358	6082242
6727-2100		323640	6091348
6727-2101		324735	6085448
6727-2102		324676	6085509
6727-2103		324708	6085482
6727-2107		324692	6085422
6727-2108		324704	6085420
6727-2110	FRL 150	326382	6092067
6727-2111		318976	6091619
6727-2112		320498	6091081
6727-2118	STY 112	319192	6092044
6727-2119	STY 117	319439	6093546
6727-2128		319794	6090645
6727-2131		324885	6090344
6727-2136	FRL 81	322795	6090867
6727-2147	BRM 167	321686	6091876
6727-2172		320152	6103690
6727-2174		319201	6095977
6727-2175		318982	6095321
6727-2176	BRM 176	321939	6086947
6727-2177		324487	6083679
6727-2178		325788	6084602
6727-2179	BRM 177	321512	6092158
6727-2180		320714	6084716
6727-2181		322758	6088363
6727-2182		321032	6089319
6727-2183	STY 116, P.23119	320635	6093759
6727-2186		324646	6090453
6727-2187		324646	6090453
6727-2190		321183	6095734
6727-2192		318492	6087229

Hole id	Names	Easting	Northing
6727-2193		332584	6089609
6727-2196	633-9548-06	320682	6093289
6727-2197	FRL 76	321882	6092362
6727-2209		318773	6096528
6727-2215		319460	6084749
6727-2218		322495	6085608
6727-2219	BRM 178	321275	6082026
6727-2221		319260	6093564
6727-2222	FRL 151	322366	6091650
6727-2225	FRL 152	321627	6093528
6727-2228	STY 113	319877	6092251
6727-2232	BRM 179	320398	6092271
6727-2233		319033	6084247
6727-2234		325711	6085237
6727-2237	FRL 160	325719	6085495
6727-2238	FRL 143	332340	6094106
6727-2239	FRL 144	332338	6094094
6727-2240		324124	6096397
6727-2241	FRL 138	324137*	6094826*
6727-2242	FRL 139	324138*	6094835*
6727-2243	STY 108	319095	6094051
6727-2244	STY 109	319097*	6094029*
6727-2245	STY 110	319063	6093944
6727-2246		320457	6093890
6727-2248		320551	6095736
6727-2249	FRL 153	324547	6090360
6727-2250	BRM 47	321831	6089509
6727-2251		321622	6088583
6727-2252	BRM 237	318337	6089456
6727-2253	FRL 231	322468*	6092765*
6727-2254	FRL 140	323662	6089417
6727-2255	FRL 141	324452	6087737
6727-2257	FRL 230	323222	6084478
6727-2258	FRL 142	324100	6085651
6727-2259	BRM 155	320564*	6086939*
6727-2260	BRM 153	321715	6085672
6727-2262	FRL 78	325931	6090344
6727-2264		320169	6085351
6727-2265	BRM 154	318923*	6086181*
6727-2266	BRM 159	322334	6086943
6727-2267	BRM 158	318882*	6082907*
6727-2268		319899	6094368
6727-2269		320986	6091107
6727-2270		320598	6091941
6727-2272	FRL 77	323432	6090138
6727-2273	BRM 51	320805	6091087
6727-2281	FRL 162	320254	6096324
6727-2286		325757	6085357
6727-2288		318926	6104015
6727-2289		322005	6085651

Hole id	Names	Easting	Northing
6727-2291		319660	6095298
6727-2295		320575	6092457
6727-2297		325029	6090321
6727-2298		319524	6090862
6727-2299	FRL 163	319919	6096765
6727-2301	BRM 41	318786	6085209
6727-2303	FRL 155	322926	6090206
6727-2304		321295	6091884
6727-2305	FRL 80	323621	6090736
6727-2307		323311	6089085
6727-2309		321357	6093368
6727-2310	FRL 157	321706	6092388
6727-2311	FRL 156	325754	6092382
6727-2312		322497	6091088
6727-2313	FRL 158	327401	6088503
6727-2314	FRL 70, P.94986	325082	6090199
6727-2315	FRL 69	322521	6087034
6727-2316	BRM 39	321863	6087875
6727-2329	FRL 71	323033*	6090243*
6727-2330	FRL 72	323033*	6090243*
6727-2331	BRM 42	321572	6092198
6727-2346	82LC3P 1	324647	6097178
6727-2358	80HRM 1	321542	6101628
6727-2359	80HRM 2	321472	6100878
6727-2360	80HRM 3	321422	6099828
6727-2361	80HRM 4	321372	6098428
6727-2362	80HRM 11	321172	6101678
6727-2363	80HRM 5	321292	6096368
6727-2364	80HRM 7	321942	6096078
6727-2365	80HRM 6	322962	6095638
6727-2366	80HRM 8	323102	6094478
6727-2367	80HRM 9	322892	6092278
6727-2368	80HRM 10	323172	6090498
6727-2369	80HRM 12	321291	6103737
6727-2370	FRL 79	325116	6090114
6727-2371		319222	6095798
6727-2372		322622	6085968
6727-2373	BRM 49, P.95862	321932	6088458
6727-2374	BRM 50	321752	6089357
6727-2375	BRM 45	321572	6092203
6727-2381		318962	6086328
6727-2382		320302	6090788
6727-2383	BRM 46	322952	6084283
6727-2387		320932	6092578
6727-2388	FRL 232	332339	6094176
6727-2389	FRL 233	327622	6096778
6727-2391		321740	6091675
6727-2397		323072	6091448
6727-2399		322732	6087948
6727-2401		321352	6092678

Hole id	Names	Easting	Northing
6727-2405		320057	6096698
6727-2406	FRL 235	324172	6085678
6727-2407	BRM 245	319051*	6086360*
6727-2408	BRM 240	318882	6082907
6727-2409	FRL 234	325422	6084428
6727-2410	BRM 241	322022	6083698
6727-2411	BRM 242	321772	6085678
6727-2412	STY 206	319097*	6094036*
6727-2413	FRL 236	324471	6087709
6727-2414	BRM 182	321136*	6089537*
6727-2415	BRM 243	321139*	6089533*
6727-2416	FRL 237	323637	6089410
6727-2417	FRL 238	327363	6088526
6727-2418	BRM 244	320561*	6086938*
6727-2419		318721	6103028
6727-2422		321032	6093218
6727-2423		320372	6092558
6727-2426	FRL 82	328739	6090312
6727-2427	BRM 247	319067	6091828
6727-2428	FRL 240	320322	6095843
6727-2429	FRL 241	325777	6092368
6727-2430	FRL 242	324802	6082348
6727-2515	LK 1	319832	6097183
6727-2516	KR9201	322812	6104198
6727-2517	KR9202	329722	6097778
6727-2518	KR9203	328662	6100118
6727-2519	KR9204	327382	6101178
6727-2522	KR9207	325172	6099578
6727-2578	MB 49	331742	6097678
6727-2579	MB 50	330802	6097978
6727-2580	MB 51	329922	6098418
6727-2581	MB 52	328852	6098958
6727-2582	MB 53	327842	6099488
6727-2583	MB 54	326992	6100258
6727-2584	MB 55	326262	6100908
6727-2585	MB 56	325302	6101288
6727-2586	MB 57	324192	6101368
6727-2587	MB 58	323232	6101558
6727-2588	MB 59	322162	6101978
6727-2589	MB 60	321232	6102378
6727-2590	MB 61	326692	6098878
6727-2591	MB 62	325702	6098878
6727-2592	MB 63	324722	6099078
6727-2593	MB 64	323692	6099258
6727-2594	MB 65	322492	6099278
6727-2595	MB 66	321422	6099298
6727-2596	MB 67	330022	6097578
6727-2597	MB 68	330022	6096438
6727-2598	MB 69	330122	6095558
6727-2599	MB 70	330112	6094458

Hole id	Names	Easting	Northing
6727-2600	MB 71	330122	6093378
6727-2601	MB 72	330202	6092368
6727-2610	FRL 165	325392	6084483
6727-2611	BRM 184	322017	6083713
6727-2612	FRL 243	324127	6095098
6727-2613	BRM 185	319062	6091788
6727-2826	BRM 14	318272	6086841
6727-2829	BRM 113	318252	6087598
6727-2830	BRM 7, DM8, 263-2776-02	318312	6089500
6727-2833		318124	6097315
6727-2834	BRM 146	318469	6081731
6727-2836	BRM 22	318347	6084909
6727-2846	BRM 225	318469	6081731
6727-2879		320337	6104215
6727-2910		319379	6104173
	AB01	319444	6104653
	AB02	307139	6088238
	AB03	308056	6087862
	AB04	308923	6087057
	AB05	320207	6094087
	AB06	318082	6083891
	AB07	315133	6093924
	AB08	316123	6094138
	AB09	316897	6083816
	AB10	315510	6083838
	AB11	317442	6092890

Obswell & other names	Hole id	Easting	Northing
BRM 1	6727-1988	319564	6091696
BRM 2	6727-1956	320883	6092166
BRM 3, Langhorne Ck. P.S.	6727-1964	321349	6092227
BRM 4	6727-2011	320852	6091446
BRM 5	6627-1315	313513	6082922
BRM 6	6627-908	318008	6090726
BRM 7, DM8, 263-2776-02	6727-2830	318312	6089500
BRM 8, BRM 107**	6727-2022	319307	6089112
BRM 9	6727-2025	319766	6088641
BRM 10	6727-2029	320231	6087848
BRM 11	6727-2071	319029	6087762
BRM 12	6627-900	317165	6087910
BRM 13	6627-895	317146	6087397
BRM 14	6727-2826	318272	6086841
BRM 15, BRM 117**	6727-2073	319816	6086859
BRM 16	6727-2074	319268	6086624
BRM 17	6727-1647	320902	6086177
BRM 18	6627-1336	314356	6085377
BRM 19	6627-1273	314801	6085002
BRM 20	6627-1251	316623	6085515
BRM 21, BRM 123**	6627-1265	316304	6084741
BRM 22	6727-2836	318347	6084909
BRM 23, BRM 128**	6727-1631	318892	6084631
BRM 24	6727-1642	319024	6084003
BRM 25	6727-1644	320039	6083258
BRM 26, BRM 141**	6727-1671	321240	6083652
BRM 27	6727-1605	320832	6082839
BRM 28	6727-1600	322036	6082235
BRM 29	6727-1612	318625	6081825
BRM 30, DM12	6627-1253	316599	6084640
BRM 31	6727-1613	318855	6082773
BRM 32, BRM 142**	6627-1290	316376	6082747
BRM 33	6627-1224	317189	6082972
BRM 34	6627-1248	317581*	6086050*
BRM 35	6627-776	316666	6080404
BRM 36	6727-1610	318773	6081365
BRM 37	6727-1606	320431	6081798
BRM 38, DM16	6627-864	312114	6086970
BRM 39	6727-2316	321863	6087875
BRM 40	6727-1619	318741	6085187
BRM 41	6727-2301	318786	6085209
BRM 42	6727-2331	321572	6092198
BRM 44	6727-1985	321407	6090780
BRM 45	6727-2375	321572	6092203
BRM 46	6727-2383	322952	6084283
BRM 47	6727-2250	321831	6089509
BRM 49, P.95862	6727-2373	321932	6088458
BRM 50	6727-2374	321752	6089357
BRM 51	6727-2273	320805	6091087

Obswell & other names	Hole id	Easting	Northing
BRM 101	6727-1987	320658	6091916
BRM 102	6727-1991	318775	6091753
BRM 103	6727-1980	321167	6091173
BRM 104	6727-2000	319401	6090858
BRM 105	6727-2014	321158	6090056
BRM 106	6727-1998	318872	6089503
BRM 107**, BRM 8	6727-2022	319307	6089112
BRM 108	6727-2043	321109	6089061
BRM 109	6727-2028	320242	6087903
BRM 110	6627-899	316789	6087933
BRM 111	6627-872	316557	6087684
BRM 112	6627-894	317018	6087435
BRM 113	6727-2829	318252	6087598
BRM 114	6627-889	318129	6087222
BRM 115	6627-875	316224	6086435
BRM 116	6627-885	318105	6086525
BRM 117**, BRM 15	6727-2073	319816	6086859
BRM 118	6727-2072	319814	6086905
BRM 119	6627-1256	316043	6085820
BRM 120	6627-1252	316947	6086221
BRM 121	6727-1648	321829	6086096
BRM 122	6727-1649	322556	6086116
BRM 123**, BRM 21	6627-1265	316304	6084741
BRM 124	6627-1244	317893	6085398
BRM 125	6627-1228	318007	6084353
BRM 126	6727-1622	318784	6085339
BRM 127	6727-1627	319323	6085212
BRM 128**, BRM 23	6727-1631	318892	6084631
BRM 129	6727-1654	320691	6084724
BRM 130	6727-1662	322319	6085508
BRM 131	6727-1664	322535	6085044
BRM 132	6627-1282	316361	6084111
BRM 133	6627-1225	317105	6084168
BRM 134	6727-1618	318598	6084049
BRM 135	6727-1640	319845	6083955
BRM 136	6727-1673	321656	6083906
BRM 137	6727-1667	322785	6084254
BRM 138	6627-1220	316944	6083106
BRM 139	6627-1218	317575	6083467
BRM 140	6727-1615	318458	6083407
BRM 141**, BRM 26	6727-1671	321240	6083652
BRM 142**, BRM 32	6627-1290	316376	6082747
BRM 143	6727-1614	319258	6082604
BRM 144	6627-1213	317444	6082172
BRM 145	6627-1204	315965	6081542
BRM 146	6727-2834	318469	6081731
BRM 147	6727-1604	321440	6082111
BRM 148	6627-1212	317610	6082253
BRM 153	6727-2260	321715	6085672
BRM 154	6727-2265	318923*	6086181*

Obswell & other names	Hole id	Easting	Northing
BRM 155	6727-2259	320564*	6086939*
BRM 156	6627-7198	312840	6084681
BRM 157	6627-7264	315900	6081499
BRM 158	6727-2267	318882*	6082907*
BRM 159	6727-2266	322334	6086943
BRM 160	6627-7199	312870	6084683
BRM 161	6627-6341	317211	6087072
BRM 162**	6627-6855	317040	6084099
BRM 163	6627-6383	316466	6085993
BRM 164	6627-1245	317781	6086190
BRM 165	6627-1246	317830	6086179
BRM 166	6627-893	317139	6087725
BRM 167	6727-2147	321686	6091876
BRM 168	6727-1657	321616	6091850
BRM 169	6727-1660	321187	6085159
BRM 170	6727-2036	320242	6087903
BRM 171	6727-2044	321063	6088592
BRM 172	6727-2060	322023	6088811
BRM 174	6727-2097	320649	6091087
BRM 175	6727-2099	321358	6082242
BRM 176	6727-2176	321939	6086947
BRM 177	6727-2179	321512	6092158
BRM 178	6727-2219	321275	6082026
BRM 179	6727-2232	320398	6092271
BRM 180	6627-7829	315560	6089380
BRM 181	6727-1412	320285	6089605
BRM 182	6727-2414	321136*	6089537*
BRM 183	6627-9170	315112	6086638
BRM 184	6727-2611	322017	6083713
BRM 185	6727-2613	319062	6091788
BRM 186	6627-788	307433	6081826
BRM 201	6727-1970	321537	6092285
BRM 202	6727-1975	321975	6091755
BRM 203	6727-1982	321633	6091090
BRM 204	6727-1989	319059	6091825
BRM 205	6727-2013	320709	6091063
BRM 206	6727-2005	319855	6089455
BRM 207	6727-1999	318337	6089456
BRM 208	6727-2038	321141	6089377
BRM 209	6727-2045	321631	6089671
BRM 210	6727-2020	322159	6090095
BRM 211	6627-948	315382	6090967
BRM 212	6727-2035	318958	6088022
BRM 213	6727-2070	320587	6087743
BRM 214	6727-2081	318880	6086610
BRM 215	6727-2077	321731	6086909
BRM 216	6727-1658	320527	6085681
BRM 217	6627-1254	316599	6084640
BRM 218	6627-1237	318143	6084599
BRM 219	6727-1659	321923	6084505

Obswell & other names	Hole id	Easting	Northing
BRM 220	6727-1672	320480	6083719
BRM 221	6627-1223	317189	6082972
BRM 222	6727-1607	320431	6081798
BRM 223	6727-1596	321540	6081963
BRM 224	6727-1611	318782	6081974
BRM 225	6727-2846	318469	6081731
BRM 226	6727-1595	320969	6081860
BRM 227	6727-1594	319762	6081518
BRM 228	6627-1199	318181	6081161
BRM 229	6727-1597	322713	6082115
BRM 230	6627-870	315122	6086596
BRM 231	6627-1335	313992	6084831
BRM 232	6627-1249	317817	6086239
BRM 233	6627-777	316666	6080404
BRM 234	6627-917	315527	6092061
BRM 235	6627-1329	315029	6083099
BRM 236	6627-935	315841	6088993
BRM 237	6727-2252	318337	6089456
BRM 238	6627-8317	307433	6081826
BRM 239	6627-8618	315857	6081463
BRM 240	6727-2408	318882	6082907
BRM 241	6727-2410	322022	6083698
BRM 242	6727-2411	321772	6085678
BRM 243	6727-2415	321139*	6089533*
BRM 244	6727-2418	320561*	6086938*
BRM 245	6727-2407	319051*	6086360*
BRM 246	6627-8619	312822	6085028
BRM 247	6727-2427	319067	6091828
BRM 248	6627-8765	317581	6086050
BRM 249	6627-8766	316652	6084633
BRM 250	6627-8767	315562	6089363
FRL 1	6727-1800	320076	6096597
FRL 2	6727-1799	320080	6096567
FRL 3	6727-1809	321585	6096545
FRL 4, DM7, 360-0099-05	6727-1798	320311	6095799
FRL 5	6727-1794	320143	6095181
FRL 6	6727-1807	320876	6094860
FRL 7	6727-1832	322604	6095169
FRL 8	6727-1853	321603	6094154
FRL 9	6727-1836	323582	6094953
FRL 10	6727-1818	322534	6093922
FRL 11, DM6	6727-1860	322367	6092736
FRL 12, DM5	6727-1861	322466*	6092763*
FRL 13	6727-1820	322821	6093139
FRL 14	6727-1841	325401	6093718
FRL 15	6727-1880	322838	6092274
FRL 16	6727-1825	323726	6092541
FRL 17	6727-1843	325427	6093118
FRL 18	6727-1846	326698	6092534
FRL 19	6727-1687	322651	6091223

Obswell & other names	Hole id	Easting	Northing
FRL 20	6727-1773	324826	6091633
FRL 21	6727-1771	326557	6091503
FRL 22	6727-1785	326871	6090869
FRL 23	6727-1442	330362	6091808
FRL 24	6727-1692	324099	6090347
FRL 25	6727-1782	325768	6090754
FRL 26	6727-1455	328653	6090537
FRL 27	6727-1479	331316	6090686
FRL 28	6727-1466	328481	6089901
FRL 29	6727-1477	329257	6090238
FRL 30	6727-1478	330196	6089856
FRL 31, 360-3573-02	6727-1704	322488	6089759
FRL 32, DM9, 360-3574-01	6727-1705	322870	6089677
FRL 33	6727-1707	322209	6089091
FRL 34	6727-1747	323761	6089416
FRL 35, DM10, 360-3569-01	6727-1698	325790	6089763
FRL 36, FRL 121	6727-1755	325624	6089153
FRL 37	6727-1758	326425	6089528
FRL 38	6727-1460	327888*	6089284*
FRL 39	6727-1738	323640	6087467
FRL 40	6727-1739	324105	6086993
FRL 41	6727-1751	325105	6087986
FRL 42	6727-1761	326929	6088451
FRL 43	6727-1468	329361	6088692
FRL 44	6727-1488	328656	6088649
FRL 45	6727-1489	328568	6087965
FRL 46, FRL 127**	6727-1490	328923	6087523
FRL 47	6727-1484	327492	6087190
FRL 48	6727-1730	323536	6086660
FRL 49	6727-1538	323828	6085815
FRL 50, 360-3606-01	6727-1525	323933	6084833
FRL 51, DM2, 360-3606-05	6727-1528	322936	6084482
FRL 52, DM1, Langhorne Creek No 1, 360-3606-03	6727-1527	323227	6084473
FRL 53	6727-1548	327221	6085478
FRL 54	6727-1499	327587	6085610
FRL 55	6727-1495	329024	6086384
FRL 56	6727-1508	329146	6084816
FRL 57	6727-1509	327684	6084281
FRL 58	6727-1579	326552	6083517
FRL 59	6727-1580	325649	6083317
FRL 60	6727-1522	323277	6083529
FRL 61	6727-1567	324166	6082351
FRL 62	6727-1679	322727*	6090915*
FRL 63	6727-1693	324237*	6090179*
FRL 64	6727-1736	322545*	6086988*
FRL 65	6727-1570	324326*	6082288*
FRL 66, DM11	6727-1470	329003	6090292
FRL 67, DM15	6727-1505	329296	6085757
FRL 68	6727-1864	321137	6092992
FRL 69	6727-2315	322521	6087034

Obswell & other names	Hole id	Easting	Northing
FRL 70, P.94986	6727-2314	325082	6090199
FRL 71	6727-2329	323033*	6090243*
FRL 72	6727-2330	323033*	6090243*
FRL 73, DM4, 360-3555-04	6727-1867	321816	6092544
FRL 74	6727-1491	328746	6087607
FRL 75	6727-1401	322032	6092298
FRL 76	6727-2197	321882	6092362
FRL 77	6727-2272	323432	6090138
FRL 78	6727-2262	325931	6090344
FRL 79	6727-2370	325116	6090114
FRL 80	6727-2305	323621	6090736
FRL 81	6727-2136	322795	6090867
FRL 82	6727-2426	328739	6090312
FRL 101	6727-1805	321207	6095667
FRL 102, 360-0099-04	6727-1797	319937	6094721
FRL 103	6727-1796	320414	6094799
FRL 104	6727-1814	321788	6095128
FRL 105	6727-1855	321641	6093500
FRL 106, FRL 154**	6727-1852	321209	6093489
FRL 107	6727-1865	321504	6093107
FRL 108	6727-1859	321845	6092725
FRL 109	6727-1873	322116	6092470
FRL 110	6727-1879	322630	6092428
FRL 111	6727-1766	323094	6091465
FRL 112	6727-1695	324238	6090506
FRL 113	6727-1777	325160	6090601
FRL 114	6727-1778	325243	6090419
FRL 115	6727-1787	326878	6090360
FRL 116	6727-1453	328673	6090616
FRL 117	6727-1457	329295	6090600
FRL 118	6727-1480	331591	6090339
FRL 119	6727-1465	328715	6089792
FRL 120	6727-1703	322567	6090169
FRL 122	6727-1712	322902	6088744
FRL 123	6727-1741	323895	6088712
FRL 124	6727-1718	322847	6088163
FRL 125	6727-1742	323627	6088239
FRL 126	6727-1727	322896	6087309
FRL 127**, FRL 46	6727-1490	328923	6087523
FRL 128	6727-1539	322989	6086065
FRL 129	6727-1754	326393	6086751
FRL 130	6727-1532	323566	6084927
FRL 131	6727-1575	325919	6084939
FRL 132	6727-1589	326506	6084619
FRL 133	6727-1576	325769	6084574
FRL 134	6727-1881	328471	6085378
FRL 135	6727-1563	325062	6084015
FRL 136	6727-1519	323501	6082978
FRL 137	6727-1520	323126	6083052
FRL 138	6727-2241	324137*	6094826*

Obswell & other names	Hole id	Easting	Northing
FRL 139	6727-2242	324138*	6094835*
FRL 140	6727-2254	323662	6089417
FRL 141	6727-2255	324452	6087737
FRL 142	6727-2258	324100	6085651
FRL 143	6727-2238	332340	6094106
FRL 144	6727-2239	332338	6094094
FRL 145	6727-1533	323074	6085179
FRL 146, P.95863	6727-1290	322955	6090759
FRL 147	6727-1544	322753	6086364
FRL 148	6727-1697	323986	6090510
FRL 149, FRL 229**	6727-2088	325072	6090342
FRL 150	6727-2110	326382	6092067
FRL 151	6727-2222	322366	6091650
FRL 152	6727-2225	321627	6093528
FRL 153	6727-2249	324547	6090360
FRL 154**, FRL 106	6727-1852	321209	6093489
FRL 155	6727-2303	322926	6090206
FRL 156	6727-2311	325754	6092382
FRL 157	6727-2310	321706	6092388
FRL 158	6727-2313	327401	6088503
FRL 159	6727-1514	329999	6087990
FRL 160	6727-2237	325719	6085495
FRL 161	6727-1655	322972	6085092
FRL 162	6727-2281	320254	6096324
FRL 163	6727-2299	319919	6096765
FRL 164	6727-1804	320767	6096077
FRL 165	6727-2610	325392	6084483
FRL 201	6727-1795	319915	6095176
FRL 202	6727-1863	322413	6092760
FRL 203	6727-1871	321772	6092421
FRL 204	6727-1876	321982	6092408
FRL 205	6727-1435	328210	6092728
FRL 206	6727-1459	330573	6091258
FRL 207	6727-1701	323221	6089935
FRL 208	6727-1714	322776	6088701
FRL 209	6727-1504	328261	6085276
FRL 210	6727-1699	325790	6089763
FRL 211	6727-1764	326180	6089044
FRL 212	6727-1492	328421	6087777
FRL 213	6727-1743	324266	6088181
FRL 214	6727-1762	326927	6086963
FRL 215	6727-1545	324713	6085968
FRL 216	6727-1737	322545*	6086987*
FRL 217	6727-1531	323227	6084473
FRL 218	6727-1552	326791	6084355
FRL 219	6727-1564	324744	6083614
FRL 220	6727-1517	323233	6082116
FRL 221	6727-1585	326571	6082640
FRL 222	6727-1824	324144	6093175
FRL 223	6727-1833	322409	6095475

Obswell & other names	Hole id	Easting	Northing
FRL 224	6727-1694	324238*	6090179*
FRL 225	6727-1680	322729*	6090916*
FRL 226	6727-1476	328721	6090308
FRL 227	6727-1847	326674	6093378
FRL 228	6727-1506	329296	6085757
FRL 229**, FRL 149	6727-2088	325072	6090342
FRL 230	6727-2257	323222	6084478
FRL 231	6727-2253	322468*	6092765*
FRL 232	6727-2388	332339	6094176
FRL 233	6727-2389	327622	6096778
FRL 234	6727-2409	325422	6084428
FRL 235	6727-2406	324172	6085678
FRL 236	6727-2413	324471	6087709
FRL 237	6727-2416	323637	6089410
FRL 238	6727-2417	327363	6088526
FRL 239	6727-1826	322264	6096851
FRL 240	6727-2428	320322	6095843
FRL 241	6727-2429	325777	6092368
FRL 242	6727-2430	324802	6082348
FRL 243	6727-2612	324127	6095098
STY 1	6727-1890	319518	6094624
STY 2	6727-1895	318746	6094044
STY 3	6727-1909	319995	6094315
STY 4	6627-1181	316906	6093095
STY 6	6627-1182	316795	6092272
STY 7, STY 107**	6727-1917	320368	6092586
STY 8	6727-1896	318992	6093811
STY 9, DM26	6727-1888	318465	6095017
STY 10, DM27	6627-1177	317511	6094635
STY 12**, STY 115**	6627-6781	318049	6096400
STY 101	6727-1911	319837	6094291
STY 102	6727-2084	320218	6093809
STY 103	6727-1897	319028	6094000
STY 104	6727-2085	320316	6093063
STY 105	6727-1898	319029	6093408
STY 106	6727-1903	318642	6092187
STY 107**, STY 7	6727-1917	320368	6092586
STY 108	6727-2243	319095	6094051
STY 109	6727-2244	319097*	6094029*
STY 110	6727-2245	319063	6093944
STY 111	6627-7180	317435	6092289
STY 112	6727-2118	319192	6092044
STY 113	6727-2228	319877	6092251
STY 114	6727-2087	321476	6092434
STY 115**, STY 12**	6627-6781	318049	6096400
STY 116, P.23119	6727-2183	320635	6093759
STY 117	6727-2119	319439	6093546
STY 201	6627-1167	317685	6096504
STY 202	6727-1887	318617	6094593
STY 203	6627-1186	318102	6093498

Obswell & other names	Hole id	Easting	Northing
STY 204	6627-1180	316855	6093807
STY 205	6727-1914	320267	6093195
STY 206	6727-2412	319097*	6094036*
STY 207	6627-8620	317437	6092308

Other names	Hole id	Easting	Northing
263-2771-03	6727-2023	319307	6089112
263-2784-03	6727-2039	321120	6089262
360-0099-04, FRL102	6727-1797	319937	6094721
360-0099-05, DM7, FRL 4	6727-1798	320311	6095799
360-2776-02, DM8, BRM 7	6727-2830	318312	6089500
360-3555-04, DM4, FRL 73	6727-1867	321816	6092544
360-3569-01, DM10, FRL 35	6727-1698	325790	6089763
360-3573-02, FRL 31	6727-1704	322488	6089759
360-3574-01, DM9, FRL 32	6727-1705	322870	6089677
360-3606-01, FRL50	6727-1525	323933	6084833
360-3606-03, DM1, FRL 52, Langhorne Creek No 1	6727-1527	323227	6084473
360-3606-04, DM3	6727-1529	323015	6084508
360-3606-05, DM2, FRL 51	6727-1528	322936	6084482
633-9548-06	6727-2196	320682	6093289
639-0062-05, DM2	6627-1170	317842	6096724
639-0067-02, DM24	6727-1885	319019	6096286
80HRM 1	6727-2358	321542	6101628
80HRM 10	6727-2368	323172	6090498
80HRM 11	6727-2362	321172	6101678
80HRM 12	6727-2369	321291	6103737
80HRM 2	6727-2359	321472	6100878
80HRM 3	6727-2360	321422	6099828
80HRM 4	6727-2361	321372	6098428
80HRM 5	6727-2363	321292	6096368
80HRM 6	6727-2365	322962	6095638
80HRM 7	6727-2364	321942	6096078
80HRM 8	6727-2366	323102	6094478
80HRM 9	6727-2367	322892	6092278
81MBR 70	6627-8147	315522	6095078
81MBR 71	6627-8148	309307	6082578
81MBR 72	6627-8149	310922	6080478
81RVP 1	6627-9018	309972	6101626
81WCP 1	6627-9017	314112	6104423
81WCP 2	6627-9019	314167	6104628
82LC3P 1	6727-2346	324647	6097178
82MB12RM 1	6627-8161	312442	6093358
AB01		319444	6104653
AB02		307139	6088238
AB03		308056	6087862
AB04		308923	6087057
AB05		320207	6094087
AB06		318082	6083891
AB07		315133	6093924
AB08		316123	6094138
AB09		316897	6083816
AB10		315510	6083838
AB11		317442	6092890
BREMER E	6727-659	320409	6109737
BREMER G	6727-276	320402	6109703

DM1, FRL 52, Langhorne Creek No 1, 360-3580-03	6727-1527	323227	6084473
DM2, FRL 51, 360-3606-05	6727-1528	322936	6084482
DM3, 360-3606-04	6727-1529	323015	6084508
DM4, FRL 73, 360-3555-04	6727-1867	321816	6092544
DM5, FRL 12	6727-1861	322466*	6092763*
DM6, FRL 11	6727-1860	322367	6092736
DM7, FRL 4, 360-0099-05	6727-1798	320311	6095799
DM8, BRM 7, 360-2776-02	6727-2830	318312	6089500
DM9, FRL 32, 360-3574-01	6727-1705	322870	6089677
DM10, FRL 35, 360-3569-01	6727-1698	325790	6089763
DM11, FRL 66	6727-1470	329003	6090292
DM12, BRM 30	6627-1253	316599	6084640
DM13	6627-922	316965	6090351
DM15, FRL 67	6727-1505	329296	6085757
DM16, BRM 38	6627-864	312114	6086970
DM17	6627-953	315387	6091332
DM18	6627-961	314278	6091947
DM19	6627-919	316070	6090840
DM21	6627-973	313607	6092463
DM22	6627-1184	317385	6091711
DM23, 639-0062-05	6627-1170	317842	6096724
DM24, 639-0067-02	6727-1885	319019	6096286
DM25,	6727-1894	319272	6095407
DM26, STY 9	6727-1888	318465	6095017
DM27, STY 10	6627-1177	317511	6094635
KR9201	6727-2516	322812	6104198
KR9202	6727-2517	329722	6097778
KR9203	6727-2518	328662	6100118
KR9204	6727-2519	327382	6101178
KR9207	6727-2522	325172	6099578
Langhorne Creek No 1, DM1, FRL 52, 360-3606-03	6727-1527	323227	6084473
Langhorne Ck. P.S., BRM 3	6727-1964	321349	6092227
LK 1	6727-2515	319832	6097183
MB 49	6727-2578	331742	6097678
MB 50	6727-2579	330802	6097978
MB 51	6727-2580	329922	6098418
MB 52	6727-2581	328852	6098958
MB 53	6727-2582	327842	6099488
MB 54	6727-2583	326992	6100258
MB 55	6727-2584	326262	6100908
MB 56	6727-2585	325302	6101288
MB 57	6727-2586	324192	6101368
MB 58	6727-2587	323232	6101558
MB 59	6727-2588	322162	6101978
MB 60	6727-2589	321232	6102378
MB 61	6727-2590	326692	6098878
MB 62	6727-2591	325702	6098878
MB 63	6727-2592	324722	6099078
MB 64	6727-2593	323692	6099258
MB 65	6727-2594	322492	6099278

MB 66	6727-2595	321422	6099298
MB 67	6727-2596	330022	6097578
MB 68	6727-2597	330022	6096438
MB 69	6727-2598	330122	6095558
MB 70	6727-2599	330112	6094458
MB 71	6727-2600	330122	6093378
MB 72	6727-2601	330202	6092368
MC 56	6727-539	321144	6104824
MC 87	6727-723	322172	6109744
MC 88	6727-724	322316	6110037
MC 92	6727-1415	325872	6101283
MC 96	6727-541	326113	6107380
P.23119, STY 116	6727-2183	320635	6093759
P.94986, FRL 70	6727-2314	325082	6090199
P.95862, BRM 49	6727-2373	321932	6088458
PD85HA 1	6627-8953	313127	6096353
STRATH BRIDGE 1	6627-9133	308197	6096903
STRATH BRIDGE 13	6627-9135	308127	6096863
STRATH BRIDGE 6	6627-9134	308072	6096838
STRATH SILO 1	6627-1128	308650	6096244

APPENDIX 2

ELEVATION OF ANGAS BREMER OBSERVATION WELLS

This table gives details of the ground elevations of the Angas Bremer Observation Well network. Locations and ground elevations of the holes are as shown on the Department of Water, Land and Biodiversity Conservation website at the beginning of February 2004. The locations were intersected with the AEM and magspec DEMs to give elevations estimated from the DEMs. These are plotted against the ground elevations as given on the web in Figure 9, to give an indication of the accuracy of the DEMs.

Differences between the elevations may be due to several factors:

- Inaccuracies in the DEMs due to error/drift in acquisition of data along flight lines
- Gridding of the DEMs between flight lines and between readings along flight lines. This assumes gradational differences between flight lines and data points along the lines, and any topographic feature that departs from the gradation is not modelled correctly
- Inaccurate locations for the observation wells leading to errors in the elevations estimated from the DEMs, as elevations at incorrect locations are calculated from the DEMs
- Errors in the ground elevation of holes given on the web. For example the ground elevation provided on the web for several holes is assumed by the data providers to be the same as the reference elevation (from which water levels are measured – eg top of casing) for the hole rather than a separately measured figure.

Hole id	Obs well number	Easting	Northing	Ground Elevation	Elevation from AEM DEM	Elevation from magspec DEM
6627-776	BRM 35	316665	6080404	3.15	-3.30	1.29
6627-777	BRM 233	316665	6080404	3.10	-3.30	1.29
6627-864	BRM 38	312113	6086970	29.46	29.34	29.53
6627-870	BRM 230	315121	6086596	17.33	16.35	17.34
6627-872	BRM 111	316556	6087684	13.92	13.66	13.63
6627-875	BRM 115	316223	6086435	11.33	10.41	12.38
6627-885	BRM 116	318104	6086525	9.45	8.89	12.01
6627-889	BRM 114	318128	6087222	11.58	10.43	12.66
6627-894	BRM 112	317017	6087435	12.23	11.25	13.51
6627-895	BRM 13	317145	6087397	11.32	11.43	12.57
6627-899	BRM 110	316788	6087933	15.00	13.53	13.66
6627-900	BRM 12	317164	6087910	13.99	12.49	13.95
6627-908	BRM 6	318007	6090726	17.16	15.40	17.07
6627-917	BRM 234	315526	6092061	30.85	28.03	28.11
6627-935	BRM 236	315840	6088993	18.13	16.56	17.99
6627-948	BRM 211	315381	6090967	27.74	26.17	27.12
6627-1167	STY 201	317684	6096504	30.72	29.61	31.96
6627-1177	STY 10	317510	6094635	31.00	25.33	26.96
6627-1180	STY 204	316854	6093807	26.48	23.73	25.06
6627-1181	STY 4	316905	6093095	23.21	23.18	24.64
6627-1182	STY 6	316794	6092272	24.02	23.69	23.88
6627-1186	STY 203	318101	6093498	23.64	22.75	23.45
6627-1199	BRM 228	318180	6081161	1.48	-0.28	1.88
6627-1204	BRM 145	315964	6081542	2.49	1.54	3.22
6627-1212	BRM 148	317609	6082253	2.99	0.26	1.63
6627-1213	BRM 144	317443	6082172	3.17	0.00	2.18
6627-1218	BRM 139	317574	6083467	3.41	2.61	3.14
6627-1220	BRM 138	316943	6083106	2.44	3.91	5.53
6627-1224	BRM 33	317188	6082972	3.03	2.18	3.11
6627-1225	BRM 133	317104	6084168	6.72	4.60	5.84
6627-1228	BRM 125	318006	6084353	5.86	3.33	5.51
6627-1237	BRM 218	318142	6084599	7.09	4.09	5.47
6627-1244	BRM 124	317892	6085398	8.80	6.88	5.88
6627-1248	BRM 34	317581	6086050	8.99	6.79	7.69
6627-1249	BRM 232	317816	6086239	8.89	7.08	8.56
6627-1251	BRM 20	316622	6085515	9.74	8.41	9.25
6627-1252	BRM 120	316946	6086221	9.43	8.90	9.66
6627-1253	BRM 30	316598	6084640	8.59	7.99	8.61
6627-1254	BRM 217	316598	6084640	8.66	7.99	8.61
6627-1256	BRM 119	316042	6085820	5.74	7.73	10.14
6627-1265	BRM 21	316303	6084741	8.75	5.61	8.57
6627-1273	BRM 19	314800	6085002	16.22	14.86	15.59
6627-1282	BRM 132	316360	6084111	7.93	5.68	8.31
6627-1290	BRM 32	316375	6082747	2.99	2.83	3.35
6627-1315	BRM 5	313512	6082922	9.56	8.12	8.54
6627-1329	BRM 235	315028	6083099	8.66	6.80	9.04
6627-1335	BRM 231	313991	6084831	16.45	16.37	15.91
6627-1336	BRM 18	314355	6085377	19.97	20.36	21.87
6627-7180	STY 111	317434	6092289	22.25	21.46	21.58
6627-7198	BRM 156	312839	6084681	17.22	15.45	15.61
6627-7199	BRM 160	312869	6084683	17.52	15.45	15.61
6627-7264	BRM 157	315899	6081499	2.97	2.16	2.78
6627-7829	BRM 180	315559	6089380	21.99	20.04	21.34
6627-8618	BRM 239	315856	6081463	3.00	2.16	2.98
6627-8619	BRM 246	312821	6085028	18.07	17.12	18.96
6627-8620	STY 207	317436	6092308	22.10	21.46	21.75
6627-8765	BRM 248	317771	6086243	9.29	7.89	8.24
6627-8766	BRM 249	316651	6084633	8.35	7.78	8.43

6627-8767	BRM 250	315562	6089363	22.54	20.04	21.51
6627-9170	BRM 183	315111	6086638	17.70	17.40	17.96
6727-1435	FRL 205	328209	6092728	12.01	12.15	7.70
6727-1442	FRL 23	330361	6091808	6.21	6.26	6.12
6727-1455	FRL 26	328652	6090537	8.80	6.00	8.77
6727-1460	FRL 38	327888	6089284	8.86	8.84	8.07
6727-1465	FRL 119	328714	6089792	6.11	3.77	4.56
6727-1466	FRL 28	328480	6089901	8.30	3.79	6.37
6727-1468	FRL 43	329360	6088692	7.49	6.86	5.19
6727-1470	FRL 66	329002	6090292	5.72	5.41	5.54
6727-1476	FRL 226	328721	6090308	7.07	4.91	5.73
6727-1477	FRL 29	329256	6090238	5.87	3.88	5.67
6727-1478	FRL 30	330195	6089856	4.38	3.37	3.01
6727-1479	FRL 27	331315	6090686	3.57	3.28	1.86
6727-1480	FRL 118	331590	6090339	3.31	3.08	3.91
6727-1484	FRL 47	327491	6087190	4.73	4.70	4.37
6727-1488	FRL 44	328655	6088649	7.07	6.16	6.59
6727-1489	FRL 45	328567	6087965	5.61	3.92	5.84
6727-1490	FRL 46	328922	6087523	8.33	4.16	7.63
6727-1492	FRL 212	328420	6087777	5.09	3.91	4.25
6727-1495	FRL 55	329023	6086384	2.49	0.79	2.43
6727-1499	FRL 54	327586	6085610	3.99	4.58	4.28
6727-1504	FRL 209	328260	6085276	4.35	2.43	3.65
6727-1505	FRL 67	329295	6085757	3.05	1.54	3.02
6727-1508	FRL 56	329145	6084816	1.81	0.63	1.23
6727-1509	FRL 57	327683	6084281	3.45	2.01	2.72
6727-1517	FRL 220	323232	6082116	1.03	0.25	0.77
6727-1522	FRL 60	323276	6083529	5.00	3.03	3.88
6727-1525	FRL 50	323932	6084833	6.10	4.93	5.02
6727-1527	FRL 52	323226	6084473	5.56	2.66	5.88
6727-1528	FRL 51	322935	6084482	7.07	4.60	4.59
6727-1531	FRL 217	323226	6084473	5.52	2.66	5.88
6727-1538	FRL 49	323827	6085815	8.11	6.58	7.45
6727-1545	FRL 215	324712	6085968	9.05	6.74	8.73
6727-1548	FRL 53	327220	6085478	4.93	3.36	5.53
6727-1552	FRL 218	326790	6084355	6.12	4.52	6.90
6727-1563	FRL 135	325061	6084015	4.50	3.30	3.31
6727-1564	FRL 219	324743	6083614	4.22	2.89	4.38
6727-1567	FRL 61	324165	6082351	3.21	0.55	1.99
6727-1570	FRL 65	324326	6082288	1.45	0.22	0.89
6727-1579	FRL 58	326551	6083517	3.12	2.13	2.89
6727-1580	FRL 59	325648	6083317	3.12	2.25	2.73
6727-1585	FRL 221	326570	6082640	1.79	-1.13	1.46
6727-1594	BRM 227	319761	6081518	1.86	-0.29	0.83
6727-1595	BRM 226	320968	6081860	1.04	0.31	-1.57
6727-1596	BRM 223	321539	6081963	0.90	-0.59	0.52
6727-1597	BRM 229	322712	6082115	1.22	0.33	2.03
6727-1600	BRM 28	322035	6082235	2.81	0.55	2.73
6727-1604	BRM 147	321439	6082111	2.80	0.82	1.63
6727-1605	BRM 27	320831	6082839	3.26	1.79	2.24
6727-1606	BRM 37	320430	6081798	2.76	0.33	1.76
6727-1607	BRM 222	320430	6081798	2.60	0.33	1.76
6727-1610	BRM 36	318772	6081365	1.97	0.57	1.40
6727-1611	BRM 224	318781	6081974	1.81	0.83	2.01
6727-1612	BRM 29	318624	6081825	3.17	1.61	2.12
6727-1613	BRM 31	318854	6082773	3.48	1.14	3.50
6727-1615	BRM 140	318457	6083407	4.49	2.54	3.56
6727-1622	BRM 126	318783	6085339	4.30	5.76	6.50
6727-1627	BRM 127	319322	6085212	7.54	5.29	5.74
6727-1631	BRM 23	318891	6084631	5.60	4.36	5.23
6727-1640	BRM 135	319844	6083955	6.11	4.28	5.51

6727-1642	BRM 24	319023	6084003	4.91	3.30	5.02
6727-1644	BRM 25	320038	6083258	5.17	3.79	4.08
6727-1647	BRM 17	320901	6086177	9.86	7.79	8.93
6727-1648	BRM 121	321828	6086096	10.09	6.61	8.48
6727-1649	BRM 122	322555	6086116	8.46	7.12	7.97
6727-1654	BRM 129	320690	6084724	7.02	5.88	6.45
6727-1658	BRM 216	320526	6085681	8.45	7.71	7.69
6727-1659	BRM 219	321922	6084505	5.76	5.33	5.55
6727-1662	BRM 130	322318	6085508	8.10	7.58	6.63
6727-1664	BRM 131	322534	6085044	6.67	5.46	5.69
6727-1667	BRM 137	322784	6084254	5.69	4.61	4.69
6727-1671	BRM 26	321239	6083652	6.01	4.38	5.27
6727-1672	BRM 220	320479	6083719	5.59	3.42	4.73
6727-1673	BRM 136	321655	6083906	5.14	4.25	4.94
6727-1679	FRL 62	322727	6090915	16.21	13.30	15.13
6727-1680	FRL 225	322729	6090916	16.23	13.30	15.13
6727-1687	FRL 19	322650	6091223	17.32	15.80	17.59
6727-1692	FRL 24	324098	6090347	13.57	12.43	12.53
6727-1693	FRL 63	324237	6090179	13.47	11.41	12.93
6727-1694	FRL 224	324238	6090179	13.44	11.41	12.93
6727-1698	FRL 35	325789	6089763	13.53	11.58	10.72
6727-1699	FRL 210	325789	6089763	13.57	11.58	10.72
6727-1701	FRL 207	323220	6089935	14.81	13.80	13.36
6727-1703	FRL 120	322566	6090169	17.82	14.99	17.86
6727-1704	FRL 31	322487	6089759	9.64	12.94	14.27
6727-1705	FRL 32	322869	6089677	15.56	12.67	14.97
6727-1707	FRL 33	322208	6089091	13.35	12.92	13.82
6727-1712	FRL 122	322901	6088744	13.20	11.26	12.93
6727-1714	FRL 208	322775	6088701	12.44	10.65	11.91
6727-1727	FRL 126	322895	6087309	10.70	7.94	8.94
6727-1730	FRL 48	323535	6086660	8.73	9.11	8.81
6727-1736	FRL 64	322545	6086988	8.94	7.43	8.79
6727-1737	FRL 216	322545	6086987	8.93	7.43	8.79
6727-1738	FRL 39	323639	6087467	10.64	9.57	12.02
6727-1739	FRL 40	324104	6086993	11.09	8.62	10.05
6727-1742	FRL 125	323626	6088239	11.90	9.66	10.90
6727-1743	FRL 213	324265	6088181	10.77	9.69	10.31
6727-1747	FRL 34	323760	6089416	12.60	13.25	11.73
6727-1751	FRL 41	325104	6087986	12.34	11.27	13.11
6727-1755	FRL 36	325623	6089153	11.42	10.05	9.03
6727-1758	FRL 37	326424	6089528	9.70	11.86	13.84
6727-1761	FRL 42	326928	6088451	7.71	10.39	10.85
6727-1762	FRL 214	326926	6086963	4.81	3.58	3.76
6727-1764	FRL 211	326179	6089044	9.21	8.48	8.94
6727-1771	FRL 21	326556	6091503	12.91	11.86	12.83
6727-1773	FRL 20	324825	6091633	19.90	19.58	20.48
6727-1782	FRL 25	325767	6090754	10.64	11.52	10.28
6727-1785	FRL 22	326870	6090869	10.49	9.32	8.50
6727-1787	FRL 115	326877	6090360	7.73	8.72	10.21
6727-1794	FRL 5	320142	6095181	26.76	24.65	24.11
6727-1796	FRL 103	320413	6094799	23.21	24.02	22.60
6727-1797	FRL 102	319936	6094721	23.45	23.05	24.70
6727-1798	FRL 4	320310	6095799	26.33	24.09	27.11
6727-1799	FRL 2	320079	6096567	25.94	26.74	26.56
6727-1800	FRL 1	320075	6096597	25.98	26.74	27.92
6727-1804	FRL 164	320766	6096077	26.11	25.29	25.76
6727-1805	FRL 101	321206	6095667	28.60	24.84	26.67
6727-1807	FRL 6	320875	6094860	22.26	21.25	22.43
6727-1809	FRL 3	321584	6096545	31.03	28.15	26.30
6727-1814	FRL 104	321787	6095128	25.37	23.43	23.68
6727-1818	FRL 10	322533	6093922	21.17	21.19	19.78

6727-1820	FRL 13	322820	6093139	20.52	18.41	18.61
6727-1824	FRL 222	324143	6093175	20.49	18.21	18.60
6727-1825	FRL 16	323725	6092541	16.69	15.81	14.34
6727-1826	FRL 239	322263	6096851	26.89	26.60	25.65
6727-1832	FRL 7	322603	6095169	23.77	23.23	23.68
6727-1833	FRL 223	322408	6095475	23.25	22.00	23.55
6727-1836	FRL 9	323581	6094953	22.23	17.76	17.87
6727-1841	FRL 14	325400	6093718	25.28	23.23	22.45
6727-1843	FRL 17	325426	6093118	11.91	20.98	19.23
6727-1846	FRL 18	326697	6092534	11.91	13.10	11.53
6727-1847	FRL 227	326673	6093378	14.20	13.64	13.21
6727-1852	FRL 106	321208	6093489	20.00	20.71	20.90
6727-1853	FRL 8	321602	6094154	22.66	19.52	22.14
6727-1855	FRL 105	321640	6093500	20.12	19.63	18.77
6727-1859	FRL 108	321844	6092725	20.19	18.18	19.70
6727-1860	FRL 11	322367	6092736	20.54	18.73	19.23
6727-1861	FRL 12	322466	6092763	21.08	18.16	20.63
6727-1863	FRL 202	322412	6092760	21.13	18.16	20.05
6727-1864	FRL 68	321136	6092992	20.72	19.80	20.03
6727-1865	FRL 107	321503	6093107	20.65	19.43	19.53
6727-1867	FRL 73	321815	6092544	18.88	18.85	18.01
6727-1871	FRL 203	321771	6092421	19.72	18.73	18.39
6727-1873	FRL 109	322115	6092470	19.33	17.58	18.49
6727-1876	FRL 204	321981	6092408	19.40	18.05	17.78
6727-1880	FRL 15	322837	6092274	16.14	16.26	14.48
6727-1887	STY 202	318616	6094593	24.58	23.63	24.41
6727-1890	STY 1	319517	6094624	23.55	22.99	23.29
6727-1895	STY 2	318745	6094044	23.73	23.75	22.82
6727-1896	STY 8	318991	6093811	22.43	20.90	22.03
6727-1897	STY 103	319027	6094000	22.57	21.38	22.89
6727-1898	STY 105	319028	6093408	22.47	21.41	21.80
6727-1903	STY 106	318641	6092187	19.19	19.75	21.28
6727-1909	STY 3	319994	6094315	23.47	22.96	24.64
6727-1911	STY 101	319836	6094291	23.12	22.12	23.06
6727-1914	STY 205	320266	6093195	20.65	18.44	20.31
6727-1917	STY 7	320367	6092586	19.05	17.97	18.60
6727-1956	BRM 2	320882	6092166	18.61	19.18	19.34
6727-1964	BRM 3	321348	6092227	18.72	18.98	17.87
6727-1970	BRM 201	321536	6092285	18.37	17.88	19.37
6727-1975	BRM 202	321974	6091755	18.65	17.62	16.91
6727-1980	BRM 103	321166	6091173	17.47	15.85	16.39
6727-1982	BRM 203	321632	6091090	16.58	16.54	17.77
6727-1987	BRM 101	320657	6091916	18.30	19.18	19.60
6727-1988	BRM 1	319563	6091696	19.82	18.13	17.69
6727-1989	BRM 204	319058	6091825	19.07	17.43	19.22
6727-1991	BRM 102	318774	6091753	20.37	18.98	21.12
6727-1998	BRM 106	318871	6089503	14.94	13.56	14.70
6727-1999	BRM 207	318336	6089456	16.98	16.77	17.63
6727-2000	BRM 104	319400	6090858	17.47	16.34	16.68
6727-2005	BRM 206	319854	6089455	15.17	13.56	15.32
6727-2013	BRM 205	320708	6091063	17.16	15.43	17.29
6727-2014	BRM 105	321157	6090056	14.92	13.40	14.57
6727-2020	BRM 210	322158	6090095	16.32	12.76	12.56
6727-2022	BRM 8	319306	6089112	15.97	12.99	14.53
6727-2025	BRM 9	319765	6088641	13.01	12.16	12.20
6727-2028	BRM 109	320241	6087903	11.57	10.47	10.63
6727-2029	BRM 10	320231	6087848	11.37	10.46	10.49
6727-2035	BRM 212	318957	6088022	12.60	11.90	12.59
6727-2038	BRM 208	321140	6089377	13.25	12.67	12.18
6727-2043	BRM 108	321108	6089061	14.00	12.30	12.34
6727-2045	BRM 209	321630	6089671	14.43	12.91	13.79

6727-2070	BRM 213	320586	6087743	11.18	10.16	10.85
6727-2071	BRM 11	319028	6087762	12.45	11.53	12.62
6727-2073	BRM 15	319815	6086859	10.76	8.86	9.68
6727-2074	BRM 16	319267	6086624	11.30	9.75	10.72
6727-2077	BRM 215	321730	6086909	10.49	10.05	9.92
6727-2081	BRM 214	318879	6086610	10.11	8.69	9.55
6727-2084	STY 102	320217	6093809	22.31	20.15	21.79
6727-2085	STY 104	320315	6093063	20.16	18.10	19.93
6727-2238	FRL 143	332340	6094106	11.23	8.12	10.67
6727-2239	FRL 144	332338	6094094	11.89	8.12	10.93
6727-2241	FRL 138	324137	6094826	29.41	26.39	28.21
6727-2242	FRL 139	324138	6094835	29.29	26.39	27.89
6727-2243	STY 108	319094	6094051	23.16	20.69	23.38
6727-2244	STY 109	319097	6094029	23.02	20.69	23.10
6727-2245	STY 110	319062	6093944	22.42	20.73	22.31
6727-2252	BRM 237	318336	6089456	17.02	16.77	17.63
6727-2253	FRL 231	322468	6092765	21.14	18.16	20.63
6727-2254	FRL 140	323661	6089417	12.93	11.55	12.81
6727-2255	FRL 141	324451	6087737	9.77	8.35	9.23
6727-2257	FRL 230	323221	6084478	5.56	2.66	5.88
6727-2258	FRL 142	324099	6085651	8.04	7.58	7.60
6727-2259	BRM 155	320564	6086939	11.16	10.17	10.94
6727-2260	BRM 153	321714	6085672	8.25	8.01	8.28
6727-2265	BRM 154	318923	6086181	9.91	6.75	9.86
6727-2266	BRM 159	322333	6086943	9.35	8.86	9.20
6727-2267	BRM 158	318882	6082907	3.84	1.68	3.84
6727-2281	FRL 162	320253	6096324	24.50	25.69	25.71
6727-2299	FRL 163	319918	6096765	33.00	32.31	31.09
6727-2301	BRM 41	318785	6085209	5.00	5.39	5.36
6727-2311	FRL 156	325753	6092382	16.33	14.80	13.15
6727-2313	FRL 158	327400	6088503	8.29	8.29	8.11
6727-2314	FRL 70	325081	6090199	10.00	10.11	11.26
6727-2329	FRL 71	323033	6090243	14.19	15.11	14.40
6727-2330	FRL 72	323033	6090243	14.19	15.11	14.40
6727-2331	BRM 42	321571	6092198	18.11	17.43	18.33
6727-2373	BRM 49	321931	6088458	11.00	11.24	11.01
6727-2374	BRM 50	321751	6089357	13.00	12.00	11.79
6727-2375	BRM 45	321571	6092203	17.78	17.43	18.33
6727-2388	FRL 232	332339	6094176	9.09	8.72	8.80
6727-2389	FRL 233	327621	6096778	19.24	18.16	19.32
6727-2406	FRL 235	324171	6085678	8.06	7.91	7.91
6727-2407	BRM 245	319051	6086360	10.10	8.99	9.71
6727-2408	BRM 240	318921	6082878	3.57	1.26	3.70
6727-2409	FRL 234	325421	6084428	4.70	3.17	4.65
6727-2410	BRM 241	322021	6083698	4.63	4.08	5.06
6727-2411	BRM 242	321771	6085678	8.03	8.49	8.20
6727-2412	STY 206	319097	6094036	22.95	20.69	23.28
6727-2413	FRL 236	324471	6087709	9.63	8.35	9.29
6727-2414	BRM 182	321136	6089537	14.24	13.11	13.42
6727-2415	BRM 243	321139	6089533	14.21	13.11	13.12
6727-2416	FRL 237	323636	6089410	12.80	11.55	13.35
6727-2417	FRL 238	327362	6088526	8.33	8.29	7.83
6727-2418	BRM 244	320561	6086938	11.35	10.17	10.94
6727-2426	FRL 82	328739	6090311	6.64	4.91	5.42
6727-2427	BRM 247	319066	6091828	19.37	17.43	19.07
6727-2428	FRL 240	320321	6095843	26.34	25.15	26.05
6727-2429	FRL 241	325776	6092368	16.14	13.40	13.54
6727-2430	FRL 242	324801	6082348	1.60	0.40	1.31
6727-2610	FRL 165	325391	6084483	4.78	2.97	3.90
6727-2611	BRM 184	322016	6083713	4.62	4.08	4.96
6727-2612	FRL 243	324126	6095098	29.24	29.79	32.18

6727-2613	BRM 185	319062	6091788	19.61	17.43	18.62
6727-2826	BRM 14	318271	6086841	11.05	10.26	9.58
6727-2829	BRM 113	318251	6087598	13.18	11.12	12.94
6727-2830	BRM 7	318311	6089500	17.10	17.28	17.93
6727-2834	BRM 146	318468	6081731	2.49	0.88	2.45
6727-2836	BRM 22	318346	6084909	5.87	4.73	4.82
6727-2846	BRM 225	318468	6081731	2.79	0.88	2.45

APPENDIX 3

ANGAS BREMER OBSERVATION WELLS DEVELOPED IN TERTIARY AQUIFER, SALINITY AND AEM CONDUCTIVITY

These data are collated to show the relationship between AEM conductivity and salinity of groundwater. Salinity and location data for the wells were downloaded from the Department of Water, Land and Biodiversity Conservation website in February 2004. The numerical average of 1999-2003 salinity measurements (considered to give a reasonable estimate of salinity at the time of the AEM survey in mid 2002), and gridded AEM CDI conductivity for the locality of the drill holes and depth of the screened interval of the bore are shown. The data are summarised in Figure 12.

Hole id	Easting	Northing	Av salinity 1999-2003 mg/l	Depth of screen	Conductivity depth interval used	Conductivity of interval mS/m
6627-776	316666	6080404	3984	30-36	30-35	139
6627-864	312114	6086970	6991	38-80	35-40	195
6627-1177	317511	6094635	1132	30-36	30-35	68
6627-1248	317581	6086050	1362	34-37	35-40	47
6627-1253	316599	6084640	1345	26-146	25-30	59
6627-6855	317040	6084099	3975	34-36	35-40	58
6627-7180	317435	6092289	2534	38-42	35-40	95
6627-7198	312840	6084681	11483	92-94	90-95	134
6627-7199	312870	6084683	7813	31-36	30-35	228
6627-7264	315900	6081499	4010	25-30	25-30	93
6627-7829	315560	6089380	1694	45-51	45-50	54
6627-9170	315112	6086638	7098	16-24	15-20	259
6727-1505	329296	6085757	5351	20-123	20-25	125
6727-1570	324326	6082288	2767	20-32	20-25	76
6727-1606	320431	6081798	1670	28-32	25-30	71
6727-1657	321616	6091850	1518	34-48	35-40	47
6727-1679	322727	6090915	2025	34-37	35-40	47
6727-1736	322545	6086988	2251	32-35	30-35	75
6727-1798	320311	6095799	2739	37-56	35-40	110
6727-1861	322466	6092763	3857	41-66	40-45	60
6727-1867	321816	6092544	1816	41-122	40-45	52
6727-2241	324137	6094826	5511	62-64	60-65	79
6727-2242	324138	6094835	5174	34-36	35-40	147
6727-2243	319095	6094051	863	76-78	75-80	33
6727-2244	319097	6094029	2602	36-42	35-40	80
6727-2245	319063	6093944	1172	58-61	55-60	46
6727-2254	323662	6089417	2446	39-42	40-45	63
6727-2255	324452	6087737	3362	31-34	30-35	66
6727-2258	324100	6085651	2608	30-36	30-35	65
6727-2259	320564	6086939	3024	30-36	30-35	65
6727-2260	321715	6085672	3457	37-40	35-40	45
6727-2265	318923	6086181	1991	39-48	40-45	44
6727-2266	322334	6086943	2137	99-101	100-105	34
6727-2267	318882	6082907	2205	30-36	30-35	57
6727-2313	327401	6088503	3579	22-28	20-25	125
6727-2329	323033	6090243	1005	64-70	65-70	41
6727-2330	323033	6090243	1094	40-46	40-45	49
6727-2375	321572	6092203	1301	36-40	35-40	58
6727-2414	321136	6089537	2762	33-42	30-35	104
6727-2426	328739	6090312	3810	20-38	20-25	108
6727-2610	325392	6084483	3431	18-28	20-25	105
6727-2611	322017	6083713	3482	29-34	30-35	76
6727-2830	318312	6089500	3030	42-48	40-45	91

APPENDIX 4

DRILLHOLES WITH BRIEF GEOLOGICAL INTERPRETATION, DOWNLOADED FROM PIRSA WEBSITE

This table was generated from geological interpretations for drill holes on the PIRSA website, downloaded in late 2002. These holes have been separated from those presented in Appendix 5 only for the purposes of easy hard copy presentation of the data. Most holes have a potential sequence of Quaternary over Tertiary over basement, but the Tertiary pinches out in the northwest, where Quaternary directly overlies basement. Holes that show data only for base Quaternary passed into Tertiary, but bottomed within the Tertiary. Holes that show data for top basement passed into basement. Holes that bottomed in the Quaternary are not shown in the table. If base Quaternary is the same depth as top basement, the Quaternary directly overlies basement, and Tertiary sediments are absent. Where base Quaternary is higher than top basement, Tertiary sediment is present between the two depths.

In most cases it appears that the distinction between Quaternary and Tertiary sediment is based on the presence of carbonate in drill materials. However, there are potential situations where clastic Quaternary sediment overlies non carbonate-bearing Tertiary, and in these cases it appears that the entire sequence has been interpreted to be Quaternary. In addition, some holes have intersected thin Pliocene sands above the limestone. It appears that these have been included as part of the Quaternary.

The data presented for drill hole 6627-1221 are probably partly in error. This is recorded as passing into basement at 39.62 m, which is very shallow compared with expected depth of at least 100 m given the regional structure of the area. Study of the driller's log of this hole showed that it passed into 'country rock' at 39.62m. It is unclear what is meant by this term, so this depth to basement has been ignored in any structural/stratigraphic interpretations. Likewise 6727-2238 is shown as having depth to base Quaternary of 48 m, whereas detailed logs in Lablack (1991) suggest it is at 16 m. The two erroneous depths are marked with an asterisk (*) in the table.

Holes that bottomed within Quaternary sediments are not included in the table, as these provide little control on boundaries between geological units.

Elevations in the table were generated by intersecting the drill hole locations with the magspec DEM.

The elevation of basement data have been used along with AEM data to generate the basement structure contours shown in Figure 33.

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6627-747	316287	6079758	0.32	18.30		-17.98	
6627-775	316503	6080293	3.09	21.30		-18.21	
6627-776	316666	6080404	1.29	30.00		-28.71	
6627-781	314822	6080380	13.99	18.30		-4.31	
6627-864	312114	6086970	29.53	23.00	69.50	6.53	-39.97
6627-868	314176	6087221	25.35	24.40		0.95	
6627-874	315978	6086922	12.72	17.40		-4.68	
6627-875	316224	6086435	12.38	18.60		-6.22	
6627-891	317382	6087175	10.23	39.30		-29.07	
6627-892	316894	6087667	13.76	34.40		-20.64	
6627-895	317146	6087397	12.57	21.30		-8.73	
6627-899	316789	6087933	13.66	30.00		-16.34	
6627-900	317165	6087910	13.95	29.60		-15.65	
6627-906	317894	6089996	18.99	41.25		-22.26	
6627-914	316725	6091308	22.81	39.60		-16.79	
6627-919	316070	6090840	24.42	47.50		-23.08	
6627-922	316965	6090351	21.51	41.15	114.30	-19.64	-92.79
6627-929	317014	6090285	21.62	39.60		-17.98	
6627-932	316028	6089614	20.83	31.50		-10.67	
6627-934	315321	6088554	24.26	19.80		4.46	
6627-936	315321	6088554	24.26	18.20		6.06	
6627-937	315149	6089292	24.15	18.90		5.25	
6627-944	314627	6089266	28.75	33.50		-4.75	
6627-953	315387	6091332	25.70	32.00	32.00	-6.30	-6.30
6627-961	314278	6091947	31.47	25.00	25.00	6.47	6.47
6627-973	313607	6092463	32.36	23.00	23.00	9.36	9.36
6627-1165	317666	6097332	27.16	19.80		7.36	
6627-1170	317842	6096724	27.63	25.00	25.00	2.63	2.63
6627-1177	317511	6094635	26.96	34.00		-7.04	
6627-1184	317385	6091711	22.22	38.00		-15.78	
6627-1196	317081	6080901	2.18	18.30		-16.12	
6627-1204	315965	6081542	3.22	19.80		-16.58	
6627-1206	316243	6081907	3.14	21.34		-18.20	
6627-1207	316603	6082041	2.24	21.34		-19.10	
6627-1212	317610	6082253	1.63	22.80		-21.17	
6627-1214	317199	6081896	2.05	22.90		-20.85	
6627-1221	317704	6083135	2.44	27.43	39.62*	-24.99	
6627-1224	317189	6082972	3.11	27.00		-23.89	
6627-1225	317105	6084168	5.84	21.34		-15.50	
6627-1228	318007	6084353	5.51	30.50		-24.99	
6627-1237	318143	6084599	5.47	31.00		-25.53	
6627-1241	317767	6085972	7.34	36.58		-29.24	
6627-1242	317456	6085748	6.93	39.60		-32.67	
6627-1245	317781	6086190	8.41	27.40		-18.99	
6627-1247	318110	6086455	11.73	33.80		-22.07	
6627-1248	317581	6086050	7.69	32.00		-24.31	
6627-1250	317154	6086113	7.59	28.35		-20.76	
6627-1252	316947	6086221	9.66	27.43		-17.77	
6627-1253	316599	6084640	8.85	24.00		-15.15	
6627-1255	316043	6085997	11.40	16.76		-5.36	
6627-1256	316043	6085820	10.14	16.80		-6.66	
6627-1257	316043	6086107	11.92	16.80		-4.88	
6627-1258	315921	6085811	10.28	16.80		-6.52	
6627-1260	315643	6085404	9.05	15.24		-6.19	
6627-1265	316304	6084741	8.57	17.70		-9.13	
6627-1267	315942	6084893	7.17	21.90		-14.73	
6627-1277	316519	6084414	9.44	22.86		-13.42	

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6627-1278	316241	6084483	7.70	22.86		-15.16	
6627-1282	316361	6084111	8.31	22.86		-14.55	
6627-1283	316448	6083046	3.60	19.20		-15.60	
6627-1289	316137	6082699	4.12	18.29		-14.17	
6627-1291	316030	6082568	3.12	18.29		-15.17	
6627-1292	316234	6082756	4.01	18.29		-14.28	
6627-1294	316232	6082392	2.72	18.30		-15.58	
6627-1296	315292	6081808	3.48	12.19		-8.71	
6627-1297	315401	6081320	5.37	16.76		-11.39	
6627-1298	315538	6081382	3.57	16.76		-13.19	
6627-1299	315466	6081560	3.44	30.50		-27.06	
6627-1301	315331	6080944	5.68	21.34		-15.66	
6627-1314	313716	6082940	10.39	19.80		-9.41	
6627-1317	312897	6081505	9.50	22.86		-13.36	
6627-1318	312814	6081501	9.27	23.77		-14.50	
6627-1320	314017	6081735	5.87	16.76		-10.89	
6627-1321	313935	6081575	6.68	19.80		-13.12	
6627-1322	314208	6081625	5.99	19.81		-13.82	
6627-1324	314466	6082003	7.72	15.24		-7.52	
6627-1325	314255	6082999	10.36	19.80		-9.44	
6627-1326	314577	6082866	7.29	19.50		-12.21	
6627-1327	314801	6082554	5.86	16.76		-10.90	
6627-1328	314846	6082611	6.05	18.28		-12.23	
6627-1330	314707	6083446	9.25	18.29		-9.04	
6627-1332	314032	6083480	13.46	22.86		-9.40	
6627-1337	314448	6085373	22.07	17.37		4.70	
6627-1340	312594	6086335	28.78	24.38		4.40	
6627-1957	317072	6084581	6.89	24.00		-17.11	
6627-1958	317446	6084435	5.55	22.50		-16.95	
6627-5996	317947	6097339	30.39	52.00	52.00	-21.61	-21.61
6627-6003	317314	6091585	23.06	33.30		-10.24	
6627-6047	318114	6086474	12.00	33.00		-21.00	
6627-6341	317211	6087072	11.45	34.00		-22.55	
6627-6383	316466	6085993	9.69	20.00		-10.31	
6627-6692	317902	6096646	27.02	28.00	28.00	-0.98	-0.98
6627-6781	318049	6096400	30.93	62.70		-31.77	
6627-6783	317740	6097479	30.31	53.00	53.00	-22.69	-22.69
6627-6792	316812	6087608	14.83	36.20		-21.37	
6627-6855	317040	6084099	4.86	19.00		-14.14	
6627-7180	317435	6092289	21.58	36.00		-14.42	
6627-7198	312840	6084681	15.61	18.00	114.00	-2.39	-98.39
6627-7199	312870	6084683	15.61	20.00		-4.39	
6627-7264	315900	6081499	2.78	18.00		-15.22	
6627-7445	315434	6092552	27.30	27.00	27.00	0.30	0.30
6627-7446	315499	6092444	26.53	23.00	23.00	3.53	3.53
6627-7742	317236	6087194	10.81	32.10		-21.29	
6627-7743	316513	6085795	10.32	20.70		-10.38	
6627-7829	315560	6089380	21.34	43.00		-21.66	
6627-7889	316083	6090991	25.15	48.80		-23.65	
6627-8039	315162	6089258	21.64	18.00		3.64	
6627-8157	317672	6097468	30.65	57.00	57.00	-26.35	-26.35
6627-8253	317652	6083448	2.94	24.50		-21.56	
6627-8268	315347	6091148	27.10	34.00	34.00	-6.90	-6.90
6627-8655	317652	6087793	12.65	38.00		-25.35	
6627-8696	316312	6091948	23.35	50.00	50.00	-26.65	-26.65
6627-9170	315112	6086638	17.96	14.00		3.96	
6727-1257	323203	6084473	6.37	16.20		-9.83	
6727-1290	322955	6090759	13.54	33.00		-19.46	
6727-1401	322032	6092298	18.02	34.00		-15.98	

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6727-1412	320285	6089605	13.87	34.00		-20.13	
6727-1433	327662	6094860	14.08	22.25		-8.17	
6727-1445	331827	6091870	5.96	14.60		-8.64	
6727-1451	329188	6095701	14.58	20.40		-5.82	
6727-1455	328653	6090537	8.77	27.40		-18.63	
6727-1456	328343	6090504	6.85	20.70		-13.85	
6727-1460	327888	6089284	8.07	21.40		-13.33	
6727-1462	328113	6090175	5.67	20.40		-14.73	
6727-1463	328146	6089914	5.36	18.30		-12.94	
6727-1464	327954	6090130	5.94	19.50		-13.56	
6727-1470	329003	6090292	5.54	17.10	115.20	-11.56	-109.66
6727-1480	331591	6090339	3.91	7.00		-3.09	
6727-1482	331491	6089264	7.73	23.47		-15.74	
6727-1486	327906	6087432	6.65	13.70		-7.05	
6727-1488	328656	6088649	6.59	18.60		-12.01	
6727-1489	328568	6087965	5.84	21.40		-15.56	
6727-1492	328421	6087777	4.25	12.00		-7.75	
6727-1493	328364	6086668	4.83	13.70		-8.87	
6727-1494	329064	6087238	5.02	18.30		-13.28	
6727-1495	329024	6086384	2.43	12.20		-9.77	
6727-1497	327961	6086095	4.05	13.57		-9.52	
6727-1498	325119	6090453	13.14	27.00		-13.86	
6727-1499	327587	6085610	4.28	12.20		-7.92	
6727-1501	327864	6085276	3.55	20.90		-17.35	
6727-1502	328678	6085325	3.72	12.20		-8.48	
6727-1505	329296	6085757	3.02	16.00	113.00	-12.98	-109.98
6727-1507	329952	6086009	1.66	12.20		-10.54	
6727-1508	329146	6084816	1.23	13.70		-12.47	
6727-1509	327684	6084281	2.72	14.60		-11.88	
6727-1511	328953	6083634	1.86	14.60		-12.74	
6727-1518	323605	6082312	2.75	18.90		-16.15	
6727-1520	323126	6083052	3.71	22.00		-18.29	
6727-1521	323122	6082934	3.11	23.50		-20.39	
6727-1527	323227	6084473	5.88	28.30	136.00	-22.42	-130.12
6727-1528	322936	6084482	4.59	28.00		-23.41	
6727-1533	323074	6085179	6.54	24.40		-17.86	
6727-1535	323473	6085367	6.16	26.00		-19.84	
6727-1539	322989	6086065	8.06	27.40		-19.34	
6727-1542	323828	6085815	7.45	33.80		-26.35	
6727-1544	322753	6086364	9.13	33.69		-24.56	
6727-1548	327221	6085478	5.53	13.57		-8.04	
6727-1550	327185	6084388	4.29	15.90		-11.61	
6727-1559	324101	6083741	4.54	23.20		-18.66	
6727-1560	324918	6083660	6.40	20.70		-14.30	
6727-1561	325037	6083629	6.86	21.30		-14.44	
6727-1562	325200	6083699	3.62	22.30		-18.68	
6727-1565	324799	6083451	5.02	18.30		-13.28	
6727-1566	324438	6082777	2.08	18.30		-16.22	
6727-1568	324170	6082550	1.84	22.90		-21.06	
6727-1570	324326	6082288	0.89	20.00		-19.11	
6727-1575	325919	6084939	5.78	18.30		-12.52	
6727-1576	325769	6084574	3.93	10.70		-6.77	
6727-1579	326552	6083517	2.89	15.20		-12.31	
6727-1580	325649	6083317	2.73	18.28		-15.55	
6727-1581	325984	6082917	1.55	19.80		-18.25	
6727-1582	325847	6082944	2.10	19.80		-17.70	
6727-1588	326430	6084765	6.77	15.20		-8.43	
6727-1591	326272	6084416	4.95	18.30		-13.35	
6727-1592	326436	6084502	4.19	16.80		-12.61	

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6727-1593	319961	6081548	0.94	19.60		-18.66	
6727-1599	322521	6083225	3.29	24.00		-20.71	
6727-1602	321957	6082228	2.88	18.09		-15.21	
6727-1603	321689	6082056	1.07	19.29		-18.22	
6727-1604	321440	6082111	1.63	23.52		-21.89	
6727-1606	320431	6081798	1.76	27.00		-25.24	
6727-1610	318773	6081365	1.40	20.00		-18.60	
6727-1612	318625	6081825	2.12	25.63		-23.51	
6727-1613	318855	6082773	3.50	24.12		-20.62	
6727-1618	318598	6084049	5.00	29.55		-24.55	
6727-1619	318741	6085187	5.56	43.71		-38.15	
6727-1621	318721	6085935	7.59	39.80		-32.21	
6727-1624	318931	6086392	10.87	31.10		-20.23	
6727-1625	319120	6085923	8.56	27.13		-18.57	
6727-1626	318941	6085699	8.78	29.55		-20.77	
6727-1628	319116	6084986	5.15	27.43		-22.28	
6727-1643	319384	6083618	4.28	27.70		-23.42	
6727-1650	322484	6085828	7.96	27.40		-19.44	
6727-1651	322215	6086139	7.03	24.40		-17.37	
6727-1653	320965	6085187	7.78	29.60		-21.82	
6727-1655	322972	6085092	5.90	23.70		-17.80	
6727-1657	321616	6091850	17.16	33.00		-15.84	
6727-1660	321187	6085159	7.48	31.40		-23.92	
6727-1661	321985	6085526	7.70	12.19		-4.49	
6727-1667	322785	6084254	4.69	23.77		-19.08	
6727-1670	323066	6083733	4.74	22.90		-18.16	
6727-1673	321656	6083906	4.94	27.40		-22.46	
6727-1676	322427	6091202	17.62	34.14		-16.52	
6727-1679	322727	6090915	15.13	34.50		-19.37	
6727-1681	322238	6091797	16.80	32.00		-15.20	
6727-1683	322194	6091840	16.95	29.26		-12.31	
6727-1686	322578	6091310	16.75	39.60		-22.85	
6727-1693	324237	6090179	12.93	33.00		-20.07	
6727-1696	324238	6090506	14.05	29.80		-15.75	
6727-1698	325790	6089763	10.72	25.90		-15.18	
6727-1700	322925	6089977	17.73	29.30		-11.57	
6727-1703	322567	6090169	17.86	30.50		-12.64	
6727-1704	322488	6089759	14.27	34.70	115.80	-20.43	-101.53
6727-1705	322870	6089677	14.97	33.50		-18.53	
6727-1710	326417	6090398	10.20	24.40		-14.20	
6727-1718	322847	6088163	11.72	33.22		-21.50	
6727-1723	322727	6088413	12.26	27.43		-15.17	
6727-1728	322920	6087323	9.39	29.90		-20.51	
6727-1731	322867	6086869	8.93	29.00		-20.07	
6727-1736	322545	6086988	8.79	27.00		-18.21	
6727-1741	323895	6088712	9.71	28.30		-18.59	
6727-1745	324805	6086829	7.28	20.90		-13.62	
6727-1748	324092	6088694	9.82	21.30		-11.48	
6727-1753	326096	6087254	10.34	21.30		-10.96	
6727-1760	327051	6088655	7.68	12.00		-4.32	
6727-1761	326929	6088451	10.85	18.30		-7.45	
6727-1762	326927	6086963	3.76	18.00		-14.24	
6727-1769	326372	6092143	16.38	22.20		-5.82	
6727-1770	326425	6092084	15.11	22.20		-7.09	
6727-1773	324826	6091633	20.48	29.90		-9.42	
6727-1774	324646	6090453	12.13	31.70		-19.57	
6727-1777	325160	6090601	13.85	29.00		-15.15	
6727-1779	325123	6090417	12.86	27.43		-14.57	
6727-1781	319539	6090465	15.84	42.00		-26.16	

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6727-1787	326878	6090360	10.21	18.30		-8.09	
6727-1788	327233	6090171	7.04	21.30		-14.26	
6727-1796	320414	6094799	22.60	34.70		-12.10	
6727-1797	319937	6094721	24.70	43.30		-18.60	
6727-1798	320311	6095799	27.11	36.60		-9.49	
6727-1799	320080	6096567	26.56	17.98		8.58	
6727-1800	320076	6096597	27.92	38.10		-10.18	
6727-1801	320579	6097090	23.20	30.20		-7.00	
6727-1802	320395	6096132	25.56	30.80		-5.24	
6727-1803	320395	6096132	25.56	32.60		-7.04	
6727-1806	320620	6095406	21.97	34.00		-12.03	
6727-1812	322255	6091728	16.77	35.00		-18.23	
6727-1816	322026	6094722	24.08	34.40		-10.32	
6727-1820	322821	6093139	18.61	27.10		-8.49	
6727-1822	323484	6093744	17.46	22.86		-5.40	
6727-1823	323629	6093288	16.62	26.82		-10.20	
6727-1825	323726	6092541	14.34	23.78		-9.44	
6727-1831	322873	6095759	23.39	42.70		-19.31	
6727-1841	325401	6093718	22.45	21.34		1.11	
6727-1844	325425	6093125	19.23	28.00		-8.77	
6727-1845	324883	6093027	19.84	24.30		-4.46	
6727-1855	321641	6093500	18.77	35.70		-16.93	
6727-1858	321592	6093267	22.29	36.60		-14.31	
6727-1859	321845	6092725	19.70	37.14		-17.44	
6727-1862	322084	6092926	19.42	14.63		4.79	
6727-1864	321137	6092992	20.03	36.58		-16.55	
6727-1865	321504	6093107	19.53	37.18		-17.65	
6727-1873	322116	6092470	18.49	32.00		-13.51	
6727-1874	322262	6092192	18.06	39.00		-20.94	
6727-1885	319019	6096286	27.66	30.10		-2.44	
6727-1886	319116	6096057	27.97	38.50		-10.53	
6727-1888	318465	6095017	25.89	32.50	68.00	-6.61	-42.11
6727-1894	319272	6095407	26.97	34.50		-7.53	
6727-1896	318992	6093811	22.03	36.88		-14.85	
6727-1897	319028	6094000	22.89	37.18		-14.29	
6727-1898	319029	6093408	21.80	35.36		-13.56	
6727-1899	321852	6089518	12.85	30.00		-17.15	
6727-1900	318952	6093363	21.50	42.00		-20.50	
6727-1904	319808	6092464	19.43	35.00		-15.57	
6727-1909	319995	6094315	24.64	36.56		-11.92	
6727-1925	321074	6092874	19.43	34.10		-14.67	
6727-1954	321038	6092159	17.52	35.05		-17.53	
6727-1962	321128	6092394	17.09	35.90		-18.81	
6727-1964	321349	6092227	17.87	32.00		-14.13	
6727-1969	321991	6091898	18.64	32.30		-13.66	
6727-1988	319564	6091696	17.69	27.13		-9.44	
6727-1994	318294	6091131	18.22	41.00		-22.78	
6727-2006	320156	6090672	15.89	35.00		-19.11	
6727-2015	321023	6089697	13.16	32.91		-19.75	
6727-2022	319307	6089112	14.53	38.10		-23.57	
6727-2023	319307	6089112	14.53	41.15		-26.62	
6727-2027	319704	6087883	11.86	29.57		-17.71	
6727-2028	320242	6087903	10.63	34.44		-23.81	
6727-2033	319776	6088713	12.50	28.65		-16.15	
6727-2036	320242	6087903	10.63	35.00		-24.37	
6727-2039	321120	6089262	12.11	35.05		-22.94	
6727-2044	321063	6088592	12.24	28.00		-15.76	
6727-2059	321915	6089234	13.14	33.22		-20.08	
6727-2060	322023	6088811	11.50	43.00		-31.50	

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6727-2066	321058	6087227	10.49	28.96		-18.47	
6727-2069	320797	6087028	10.06	36.00		-25.94	
6727-2071	319029	6087762	12.62	29.87		-17.25	
6727-2072	319814	6086905	10.07	31.10		-21.03	
6727-2073	319816	6086859	9.68	32.00		-22.32	
6727-2074	319268	6086624	10.72	24.40		-13.68	
6727-2075	319729	6086748	9.60	31.10		-21.50	
6727-2079	318497	6086761	10.37	29.90		-19.53	
6727-2080	318627	6087737	12.68	29.90		-17.22	
6727-2082	322432	6091208	17.62	36.00		-18.38	
6727-2084	320218	6093809	21.79	33.50		-11.71	
6727-2087	321476	6092434	17.02	33.00		-15.98	
6727-2088	325072	6090342	12.16	27.00		-14.84	
6727-2097	320649	6091087	16.89	33.00		-16.11	
6727-2098	327477	6094841	16.10	24.00		-7.90	
6727-2099	321358	6082242	1.81	21.30		-19.49	
6727-2100	323640	6091348	15.03	32.90		-17.87	
6727-2101	324735	6085448	7.58	29.00		-21.42	
6727-2102	324676	6085509	7.71	26.00		-18.29	
6727-2103	324708	6085482	7.67	27.00		-19.33	
6727-2107	324692	6085422	7.18	27.00		-19.82	
6727-2108	324704	6085420	7.23	26.50		-19.27	
6727-2110	326382	6092067	14.87	22.20		-7.33	
6727-2111	318976	6091619	20.02	43.00		-22.98	
6727-2112	320498	6091081	16.79	32.00		-15.21	
6727-2128	319794	6090645	14.05	33.60		-19.55	
6727-2131	324885	6090344	12.87	27.00		-14.13	
6727-2174	319201	6095977	27.15	34.00		-6.85	
6727-2175	318982	6095321	25.90	39.00		-13.10	
6727-2176	321939	6086947	9.07	25.00		-15.93	
6727-2177	324487	6083679	3.27	25.00		-21.73	
6727-2178	325788	6084602	3.98	15.00		-11.02	
6727-2179	321512	6092158	18.43	32.50		-14.07	
6727-2180	320714	6084716	6.58	32.00		-25.42	
6727-2181	322758	6088363	12.13	25.00		-12.87	
6727-2182	321032	6089319	12.47	21.00		-8.53	
6727-2183	320635	6093759	22.16	34.00		-11.84	
6727-2186	324646	6090453	12.13	29.00		-16.87	
6727-2187	324646	6090453	12.13	30.00		-17.87	
6727-2190	321183	6095734	26.01	30.50		-4.49	
6727-2192	318492	6087229	12.13	39.00		-26.87	
6727-2193	332584	6089609	2.09	27.00		-24.91	
6727-2196	320682	6093289	19.01	34.00		-14.99	
6727-2197	321882	6092362	18.48	32.00		-13.52	
6727-2209	318773	6096528	24.37	27.00		-2.63	
6727-2215	319460	6084749	5.45	34.00		-28.55	
6727-2218	322495	6085608	6.58	25.80		-19.22	
6727-2219	321275	6082026	1.51	24.90		-23.39	
6727-2221	319260	6093564	21.30	34.00		-12.70	
6727-2222	322366	6091650	17.17	35.00		-17.83	
6727-2225	321627	6093528	18.75	34.00		-15.25	
6727-2228	319877	6092251	19.89	35.00		-15.11	
6727-2232	320398	6092271	17.48	34.00		-16.52	
6727-2233	319033	6084247	5.36	30.00		-24.64	
6727-2234	325711	6085237	5.81	22.00		-16.19	
6727-2238	332264	6094238	11.25	48.00*	74.60	-36.75	-63.35
6727-2239	332255	6094149	10.93	48.00		-37.07	
6727-2240	324124	6096397	36.34	32.00		4.34	
6727-2241	324137	6094826	28.21	34.00	71.00	-5.79	-42.79

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6727-2242	324138	6094835	27.89	33.00		-5.11	
6727-2243	319095	6094051	23.38	36.00	98.40	-12.62	-75.02
6727-2244	319097	6094029	23.10	35.50		-12.40	
6727-2245	319063	6093944	22.31	36.00		-13.69	
6727-2246	320457	6093890	22.34	36.00		-13.66	
6727-2248	320551	6095736	22.59	38.50		-15.91	
6727-2249	324547	6090360	11.70	28.50		-16.80	
6727-2250	321831	6089509	12.00	33.00		-21.00	
6727-2251	321622	6088583	11.70	31.00		-19.30	
6727-2254	323662	6089417	12.81	33.00		-20.19	
6727-2255	324452	6087737	9.23	28.00		-18.77	
6727-2258	324100	6085651	7.60	28.00		-20.40	
6727-2259	320564	6086939	10.94	28.00		-17.06	
6727-2260	321715	6085672	8.28	30.00		-21.72	
6727-2262	325931	6090344	9.20	20.80		-11.60	
6727-2264	320169	6085351	7.06	30.00		-22.94	
6727-2265	318923	6086181	9.86	40.00		-30.14	
6727-2266	322334	6086943	9.20	25.00	120.00	-15.80	-110.80
6727-2267	318882	6082907	3.84	29.10		-25.26	
6727-2268	319899	6094368	22.39	38.00		-15.61	
6727-2269	320986	6091107	17.58	31.80		-14.22	
6727-2270	320598	6091941	16.99	35.20		-18.21	
6727-2272	323432	6090138	13.81	33.00		-19.19	
6727-2273	320805	6091087	16.46	31.00		-14.54	
6727-2281	320254	6096324	25.71	31.00		-5.29	
6727-2286	325757	6085357	5.52	19.50		-13.98	
6727-2289	322005	6085651	7.75	34.00		-26.25	
6727-2291	319660	6095298	25.13	27.40		-2.27	
6727-2295	320575	6092457	18.30	30.50		-12.20	
6727-2297	325029	6090321	12.87	27.40		-14.53	
6727-2298	319524	6090862	15.94	35.00		-19.06	
6727-2299	319919	6096765	31.23	40.00		-8.77	
6727-2301	318786	6085209	5.36	30.40		-25.04	
6727-2303	322926	6090206	13.67	30.00		-16.33	
6727-2304	321295	6091884	17.43	36.25		-18.82	
6727-2305	323621	6090736	12.81	28.50		-15.69	
6727-2307	323311	6089085	11.88	32.50		-20.62	
6727-2309	321357	6093368	22.23	36.50		-14.27	
6727-2310	321706	6092388	18.29	31.00		-12.71	
6727-2311	325754	6092382	13.15	21.00		-7.85	
6727-2312	322497	6091088	17.38	30.00		-12.62	
6727-2313	327401	6088503	8.11	20.50		-12.39	
6727-2314	325082	6090199	11.26	24.00		-12.74	
6727-2315	322521	6087034	8.80	24.00		-15.20	
6727-2316	321863	6087875	10.37	30.00		-19.63	
6727-2329	323033	6090243	14.40	32.00		-17.60	
6727-2330	323033	6090243	14.40	32.00		-17.60	
6727-2331	321572	6092198	18.33	31.00		-12.67	
6727-2370	325116	6090114	10.89	30.50		-19.61	
6727-2371	319222	6095798	26.96	41.60		-14.64	
6727-2372	322622	6085968	10.38	29.10		-18.72	
6727-2373	321932	6088458	11.01	30.50		-19.49	
6727-2374	321752	6089358	11.79	33.00		-21.21	
6727-2375	321572	6092203	18.33	31.00		-12.67	
6727-2381	318962	6086328	10.83	35.70		-24.87	
6727-2382	320302	6090788	14.87	33.30		-18.43	
6727-2383	322952	6084283	5.26	24.50		-19.24	
6727-2387	320932	6092578	18.78	34.30		-15.52	
6727-2391	321740	6091675	16.97	36.00		-19.03	

Hole id	Easting	Northing	Elevation (radar DEM)	Depth base Quaternary	Depth top basement	Elev base Quaternary	Elev top basement
6727-2397	323072	6091448	16.08	35.50		-19.42	
6727-2399	322732	6087948	11.54	31.50		-19.96	
6727-2401	321352	6092678	18.73	32.00		-13.27	
6727-2405	320057	6096698	30.59	33.00		-2.41	
6727-2414	321136	6089537	13.42	31.00		-17.58	
6727-2422	321032	6093218	20.87	36.50		-15.63	
6727-2423	320372	6092558	18.56	32.70		-14.14	
6727-2426	328739	6090312	5.42	17.00		-11.58	
6727-2610	325392	6084483	3.90	16.50		-12.60	
6727-2611	322017	6083713	4.96	27.60		-22.64	
6727-2613	319062	6091788	18.62	36.00		-17.38	
6727-2829	318252	6087598	12.94	40.23		-27.29	
6727-2830	318312	6089500	17.93	39.60		-21.67	
6727-2833	318124	6097315	32.03	24.70	24.70	7.33	7.33
6727-2834	318469	6081731	2.45	24.30		-21.85	
6727-2836	318347	6084909	4.82	28.90		-24.08	

APPENDIX 5

DRILLHOLES WITH DETAILED GEOLOGICAL INTERPRETATION, DOWNLOADED FROM PIRSA WEBSITE

These holes have been separated from those presented in Appendix 4 for the purposes of easy hard copy presentation of the data. They are arranged in order of map sheet – unit number. The word Strathalbyn has been abbreviated to Strath in the table. Some long descriptions appear to be truncated on the website – they appear to be limited to 128 characters.

The table has been set up so that sequential units recognised in the holes are on consecutive pages.

The geological units identified use the prefixes Q for Quaternary, T for Tertiary, CP for Carboniferous/Permian, E for Cambrian, and NK for undifferentiated basement (Neoproterozoic to Cretaceous).

Elevations of the holes have been estimated by intersecting the locations with the magspec DEM. Data from several holes just outside the study area are included in the table as the information from these holes was considered important. No elevations are shown for these holes.

There are additional holes shown on the PIRSA website for the study area, but these are not included as they are drilled in basement-dominated areas and intersected basement below thin soil cover.

Hole name	Hole id	Easting	Northing	Elev	Unit 1
STRATH SILO 1	6627-1128	308650	6096244	68.11	0.00-2.82 Qhr SAND CLYU Sand, clayey, fine grained, & clay, fine sandy, calcareous, light red/brown.
81MBR 70	6627-8147	315522	6095078	35.27	0.00-26.20 Q CLYU SAND Clay, yellow/brown-green/grey, sandy in part, & sand, fine-coarse grained, pebbly in places, loose.
81MBR 71	6627-8148	309307	6082578		0.00-19.30 TQ CLYU SAND Clay, grey-red-brown, sandy & silty very fine-medium grained, silty sand at base.
81MBR 72	6627-8149	310922	6080478		0.00-1.40 Q\ca CALC Calcrete, off-white, moderately hard.
82MB12RM 1	6627-8161	312442	6093358	41.77	0.00-14.00 Q CLYU GRVL Clay, red-brown, minor fine magnetite, over gravel of maghemite, laterite, quartz; very magnetic.
PD85HA 1	6627-8953	313127	6096353	100.30	0.00-6.00 Q SAND CLYU Sand, medium-coarse, brown-orange/red, calcareous clay at base.
81WCP 1	6627-9017	314112	6104423	111.38	0.00-6.00 Q SOIL Soil & subsoil, may include weathered schist.
81RVP 1	6627-9018	309972	6101626	179.46	0.00-2.00 Q SOIL Soil & subsoil.
81WCP 2	6627-9019	314167	6104628	123.39	0.00-2.00 Q SOIL Soil & subsoil
STRATH BRIDGE 1	6627-9133	308197	6096903	71.96	0.00-0.61 ?Q\ca SAND ?CALC Pale brown sandy & silty loam with limestone rubble & abundant small lime nodules.
STRATH BRIDGE 6	6627-9134	308072	6096838	71.82	0.00-0.46 Qh SOIL Brown silty & sandy loam with occasional small lime nodules.
STRATH BRIDGE 13	6627-9135	308127	6096863	71.71	0.00-4.27 Qha SAND SILT Fine sand & silt, wet.
BREMER G	6727-276	320402	6109703	65.91	0.00-12.19 Qha SAND GRVL Sand, silty & clayey, over clayey coarse sand, grit & gravel.
MC 56	6727-539	321144	6104824	71.64	0.00-3.00 Tym LMST SILT Limestone, silty, fossiliferous, orange.
MC 96	6727-541	326113	6107380		0.00-0.20 Q SOIL Soil, brown, sandy, silty.
BREMER E	6727-659	320409	6109737	69.92	0.00-5.78 Qha GRVL SAND Gravel, grit, coarse sand, some slate chips below 4m.
MC 87	6727-723	322172	6109744	71.57	0.00-0.70 ?Qhac SOIL CLYU Soil, brown, clayey, silty & sandy.
MC 88	6727-724	322316	6110037		0.00-0.60 ?Qhac SAND CLYU Sand, red-brown, fine, clayey.
DM3	6727-1529	323015	6084508	5.93	0.00-3.66 ?Qem SAND SILT Sand, fine-medium grained, sub-angular ironstained quartz, abumdant silt, rare clay, brown.
DM4	6727-1867	321816	6092544	18.01	0.00-22.86 ?TpQlb CLYU SAND Clay, sandy, fine grained quartz, minor sandy interbeds, non-calcareous, dark grey-light brown.
82LC3P 1	6727-2346	324647	6097178	29.97	0.00-22.00 Q SAND CLYU Sand & clay, orange-brown, slightly micaceous.
80HRM 1	6727-2358	321542	6101628	65.55	0.00-8.00 Q\ca CALC CLYU Calcrete, yellow, clayey towards base.
80HRM 2	6727-2359	321472	6100878	69.57	0.00-30.00 ?Q CALC CLYU Calcrete overlying mottled silty clay and calcrete with sandy silt.
80HRM 3	6727-2360	321422	6099828	51.19	0.00-30.00 ?Q SAND CLYU Calcrete over variable clay, silt & sand.
80HRM 4	6727-2361	321372	6098428	23.28	0.00-24.00 Q CLYU CALC CLAY,RED-BROWN & GRAVELLY
80HRM 11	6727-2362	321172	6101678	59.24	0.00-2.00 Q\ca CALC CALCRETE
80HRM 5	6727-2363	321292	6096368	29.94	0.00-30.00 Q CLYU RED-BROWN CLAY
80HRM 7	6727-2364	321942	6096078	24.44	0.00-38.00 Q CLYU MOTLED RED-BROWN-GREEN CLAY
80HRM 6	6727-2365	322962	6095638	20.71	0.00-28.00 Q CLYU SILT RED-BROWN CLAY OVER GREY CLAYEY SILT.
80HRM 8	6727-2366	323102	6094478	17.56	0.00-26.00 Q CLYU MOTTLED RED-BROWN-GREY CLAY
80HRM 9	6727-2367	322892	6092278	15.83	0.00-32.00 Q CLYU MOTTLED YELLOW-BROWN-GREY CLAY
80HRM 10	6727-2368	323172	6090498	13.40	0.00-28.00 Q CLYU SILT BROWN & BROWN-GREY MOTTLED SILTY CLAY
80HRM 12	6727-2369	321291	6103737	60.88	0.00-2.00 Q\ca CALC CALCRETE
LK 1	6727-2515	319832	6097183	29.66	0.00-70.10 ns No core .
KR9201	6727-2516	322812	6104198	71.82	0.00-2.00 Q\ca CALC Calcrete, pale red-brown.
KR9202	6727-2517	329722	6097778	13.21	0.00-12.00 Qa SAND SILT Sand, quartzose, clayey, sandy silt in part, fine grained, light grey-brown.
KR9203	6727-2518	328662	6100118	34.48	0.00-2.00 Q\ca CALC CLYU Sandy clay & calcrete, light grey-brn.
KR9204	6727-2519	327382	6101178	71.19	0.00-2.00 Q\ca CALC SAND Calcrete & calcareous quartzose sand, pale grey-yellow.
KR9207	6727-2522	325172	6099578	90.11	0.00-8.00 Q\ca CLYU CALC Calcrete & calcareous quartz sand over fine sandy clay, pale yellow-brown.
MB 59	6727-2588	322162	6101978	55.53	0.00-22.00 Tp3 SAND CLYU Sand, fine-medium, quartzose, calcareous, clayey, light yellow/brown-orange/brown; HM to 0.53%.
MB 66	6727-2595	321422	6099298	28.63	0.00-8.00 Qa SILT SAND Silt, sandy, very fine grained, micaceous, brown; HM to 0.62%.

Hole name	Unit 2
STRATH SILO 1	2.82-17.83 Ek SCHT SDST Quartz-mica schist, interlayered fine sandstone, completely weathered to micaceous clay at top, fresher
81MBR 70	26.20-26.40 NK1 MCDL Micro-dolerite, dark green/grey, hard.
81MBR 71	19.30-57.90 Ty LMST SAND Limestone, yellow/brown, weakly cemented, lesser calcareous sand, sparse fragmented shells & crinoids.
81MBR 72	1.40-27.50 TQ CLYU SAND Clay, light grey-grey/brown, silty, soft, sandy, fine-medium grained, quartzose, & clayey sand.
82MB12RM 1	14.00-26.50 ?Ek SCHT CLYU Biotite sericite quartz felspar schist, weathered to green-grey clay at top.
PD85HA 1	6.00-94.00 Ek PHYL SCHT Interbedded grey fine-medium micaceous phyllite & fine-medium siliceous quartz-biotite-schist; trace py
81WCP 1	6.00-92.00 Ek QTZT SCHT Quartzite, fine-medium, narrow interbedded lenses of quartz-biotite schist; trace-2% pyrite/pyrrhotite.
81RVP 1	2.00-42.00 Ek GYWK SCHT Metagreywacke, dark grey, narrow interbeds of quartz biotite schist; rare trace pyrite.
81WCP 2	2.00-114.00 Ek QTZT SCHT Quartzite, fine-medium, light grey, interbedded lenses of quartz-biotite schist; trace - 2% pyrite.
STRATH BRIDGE 1	0.61-4.56 Qha CLYU SILT Clay, silty & sandy, micaceous, red/brown, wet, soft.
STRATH BRIDGE 6	0.46-8.37 Qha CLYU SAND Clay, sandy, & sand, clayey, grey-grey/brown, some blue/grey mottling, wet, moist.
STRATH BRIDGE 13	4.27-4.88 Ek SDST Micaceous sandstone.
BREMER G	12.19-15.54 Ek SLAT Slate hornfels with quartz.
MC 56	
MC 96	0.20-4.00 ?TpQlb CLYU SAND Clay, calcareous towards top, 10-40% fine sand, pale orange/brown-grey/brown mottled, minor purple p
BREMER E	5.78-5.79 Ek SLAT Slate chips, sand & gravel.
MC 87	0.70-3.80 ?Qpap CLYU SAND Clay, red-brown, 35% fine & medium sand, 15% calcrete & rare ferricrete fragmants.
MC 88	0.60-3.80 ?Qpap CLYU SAND Clay, red-brown, plastic, 20% fine sand, minor calcrete.
DM3	3.66-12.80 TpQlb CLYU SILT Clay, silty, trace sand, dark brown-light brown.
DM4	22.86-35.05 ?Tpp SAND CLYU Sand, fine grained, sub-rounded quartz, silty & clayey, non-calcareous, minor clay interbed, grades
82LC3P 1	22.00-30.00 T SAND SILT Sand & silt, pink-white, calcareous, fossil fragments.
80HRM 1	8.00-26.00 ?Qpeo SAND Sand, red-brown, unconsolidated, calcareous; blue grey clay at base.
80HRM 2	30.00-32.00 ?Tym No sample return; penetrated hard band ?limestone at 30m.
80HRM 3	30.00-32.00 ?Tym Lost circulation at 30m in presumed limestone.
80HRM 4	24.00-55.00 Ty LMST MARL BRYOZOAL LIMESTONE; MARL 46-48m.
80HRM 11	2.00-36.00 TpQlb CLYU SAND CLAY, MOTTLED TAN & CREAM, SANDY INTERBEDS
80HRM 5	30.00-65.00 Ty LMST MARL FOSSILIFEROUS LIMESTONE & MARLS
80HRM 7	38.00-74.00 Ty LMST MARL FOSSILIFEROUS LIMESTONES & MARLS, COMMONLY GLAUCONITIC.
80HRM 6	28.00-76.00 Ty LMST SAND FOSSILIFEROUS LIMESTONE, MAINLY SANDY, MINOR GLAUCONITE.
80HRM 8	26.00-76.00 Ty LMST MARL FOSSILIFEROUS LIMESTONE & MARL, COMMONLY GLAUCONITIC.
80HRM 9	32.00-80.00 Ty LMST MARL FOSSILIFEROYS LIMESTONES & MARLS, COMMONLY GLAUCONITIC.
80HRM 10	28.00-98.00 Ty LMST MARL FOSSILIFEROUS LIMESTONE & MARL, COMMONLY GLAUCONITIC.
80HRM 12	2.00-14.00 TpQlb CLYU SAND CLAY, TAN & BLUE-GREEN, SANDY.
LK 1	70.10-74.37 ?Tym LMST SDST Limestone, massive, unfossiliferous, over soft calcareous sandstone.
KR9201	2.00-4.00 Tp3 SAND Sand, quartzose, calcareous, fine-medium, light yellow-brown.
KR9202	12.00-18.00 Tp3 SAND Sand, quartzose, calcareous towards base, fine grained, light brpown-yellow.
KR9203	2.00-10.00 Tp3 SAND CLYU Sand, quartzose, fine, clayey, yellow-brown.
KR9204	2.00-8.00 Qem SAND Sand, quartzose, calcareous, fine grained, pale grey-orange.
KR9207	8.00-24.00 Tp3 SAND Sand, quartzose, fine grained, pale red-yellow.
MB 59	22.00-23.00 Tym LMST Limestone, pale yellow/brown.
MB 66	8.00-16.00 Tp3 SAND SILT Sand, quartzose, silty, very fine-fine, yellow/brown; HM to 0.4%.

Hole name	Unit 3
STRATH SILO 1	
81MBR 70	
81MBR 71	57.90-84.40 Tome SILT SAND Silt, grey-green/grey, calcareous, glauconitic, common marine shell fragments towards top, marly at
81MBR 72	27.50-88.80 Ty LMST SAND Limestone, sandy bands, yellow/brown, weakly cemented, sparse shell fragments, over silty calcareous s
82MB12RM 1	
PD85HA 1	
81WCP 1	92.00-142.00 Ek QTZT Quartzite, micaceous, light green-grey; up to 10% pyrite/pyrrhotite; un-mineralised + quartz-biotite schis
81RVP 1	42.00-70.00 Ek SCHT Quartz-biotite-garnet-sillimanite schist, malachite & azurite mineralisation.
81WCP 2	114.00-182.00 Ek QTZT SCHT 114-152 quartzite, light green-grey, micaceous, up to 3% pyrite; 152-166 quartz-biotite schist, dark
STRATH BRIDGE 1	4.56-4.57 Ek ?SCHT Very hard (refusal of auger) - probable bedrock.
STRATH BRIDGE 6	8.37-8.38 Ek ?SCHT Very hard (refusal of auger) - probable bedrock.
STRATH BRIDGE 13	
BREMER G	
MC 56	
MC 96	4.00-17.40 Tpp SAND CLYU Sand, very fine-fine, slightly clayey, yellow/brown - orange/brown.
BREMER E	
MC 87	3.80-5.20 Tpp SAND Sand, fine grained, some coarse, rare gravel, rare clay, yellow-brown.
MC 88	3.80-13.60 Tpp SAND CLYU Sand, very fine - fine & some coarse, silty in part, yellow orange, silty clay in top 1.3m.
DM3	12.80-25.91 Tpp SAND CLYU Sand, fine-medium grained, sub-rounded claer & ironstained quartz, trace mica, silty, minor sandy cla
DM4	35.05-79.55 Ty LMST CLYU Limestone, sandy, coarse, hard, re-crystallised in part, alternating hard & soft bands, interbedded sa
82LC3P 1	30.00-64.00 NK1 UINT Altered layered pyroxenitic to peridotitic intrusive; 1-7% magnetite.
80HRM 1	26.00-34.00 Tym LMST SAND Limestone, buff, minor rounded quartz sand
80HRM 2	
80HRM 3	
80HRM 4	55.00-66.00 Tr CLYU CARBONACEOUS CLAY,FOSSILIFEROUS
80HRM 11	36.00-54.00 Ty LMST SAND SANDY LIMESTONE & SANDS, FOSSILIFEROUS.
80HRM 5	65.00-76.00 Tr CLYU SAND LIGNITIC CLAY, SANDY & FOSSILIFEROUS AT BASE.
80HRM 7	74.00-104.00 Tr CLYU LMST LIGNITIC FOSS. CLAY & LIMESTONE, MINOR SAND.
80HRM 6	76.00-106.00 Tr CLYU SAND LIGNITIC CLAYS,SANDS & LIMESTONE
80HRM 8	76.00-118.00 Tr CLYU LMST LIGNITIC FOSSILIFEROUS CLAY & LIMESTONE
80HRM 9	80.00-118.00 Tr CLYU LMST LIGNITIC CLAYS & LIMESTONES, FOSSILIFEROUS.
80HRM 10	98.00-126.00 Tr CLYU LMST LIGNITIC CLAY & FOSSILIFEROUS GLAUCONITIC LIMESTONE.
80HRM 12	14.00-24.00 Q GRVL CLYU QUARTZ RICH GRAVELS,MINOR CLAYS
LK 1	74.37-81.38 ?Teob LMST CLYU Limestone, fossiliferous, medium grey, with interbedded dark brown sandy clay & thin peat layers.
KR9201	4.00-84.00 Tym LMST SDST Limestone, sandy, fine-coarse, minor clay, over sandstone, calcareous, clayey, and unconsolidated foss
KR9202	18.00-52.00 Tym LMST SDST Limestone, fine, clayey, & sandstone, calcareous, quartzose, fine, minor unconsolidated quartz grave
KR9203	10.00-26.00 Tym SAND LMST Sand , quartzose, calcareous, & sandy limestone, fine grained, light grey-yellow.
KR9204	8.00-24.00 Tp3 SAND Sand, quartzose, fine grained, medium brown.
KR9207	24.00-56.00 Tym SAND Sand, quartzose, calcareous, fine grained, light red-yellow.
MB 59	
MB 66	16.00-20.00 ?Tym SDST Sandstone, calcareous, quartzose, fine grained, light grey/yellow.

Hole name	Unit 4
STRATH SILO 1	
81MBR 70	
81MBR 71	84.40-104.00 Tr SAND SILT Clay, grey, slightly silty, firm, over sand, silty, fine-medium grained, becoming very coarse, angula
81MBR 72	88.80-107.80 Tome MARL SAND Marl, sandy towards top, silty bands, green-grey, glauconitic.
82MB12RM 1	
PD85HA 1	
81WCP 1	
81RVP 1	
81WCP 2	
STRATH BRIDGE 1	
STRATH BRIDGE 6	
STRATH BRIDGE 13	
BREMER G	
MC 56	
MC 96	
BREMER E	
MC 87	5.20-12.50 Ek PHYL CLYU Phyllite, dark grey, largely weathered to grey-green clay.
MC 88	13.60-20.40 Ek CLYU PHYL Clay, pale green-yellow, silty, fragments of grey-green weathered phyllite, becoming yellow & purple w
DM3	25.91-111.25 Ty LMST SAND Limestone, weak-moderate cement, fossiliferous, minor quartz, light yellow/brown, over fine quartz s
DM4	79.55-112.78 ?Teob SAND CLYU Sand, fine grained quartz, calcareous silt, light grey; black carbonaceous clay in top 2m, calcare
82LC3P 1	
80HRM 1	
80HRM 2	
80HRM 3	
80HRM 4	66.00-84.00 Ek CLYU ?MDST WEATHERED BASEMENT; BLUE-GREY CLAY; MAFIC CHIPS, PELITE CHIPS AT BASE.
80HRM 11	54.00-86.00 Tome MARL SILC MARLS & SILCRETE INTERBEDS
80HRM 5	76.00-78.00 Ek QTZT QUARTZITE
80HRM 7	104.00-108.00 ?Ek CLYU GREEN CLAY ?WEATHERED BASEMENT.
80HRM 6	106.00-110.00 Ek CLYU SCHT WEATHERED BASEMENT,BLUE-GREEN CLAY & SCHISTOSE FRAGMENTS.
80HRM 8	118.00-124.00 Ek QTZT QUARTZITE
80HRM 9	118.00-129.00 Ek QTZT QUARTZITE, FINE GRAINED, TRACE PYRITE.
80HRM 10	126.00-130.00 Ek QTZT QUARTZITE, RED-GREY, FINE GRAINED, MICACEOUS.
80HRM 12	24.00-46.00 Ty LMST SAND SANDY LIMESTONE
LK 1	81.38-88.85 Ek GYWK Greywacke, light grey, fresh, disturbed (?) and cemented with fossiliferous limestone in top 1m, weakly bed
KR9201	84.00-98.00 Ek ?CLST SCHT Micaceous ?claystone (clay, quartz, mica), medium khaki, ?highly weathered schist, over mica-quartz s
KR9202	52.00-60.00 ?Tome LMST Limestone, graphitic, pyritic, dark blue.
KR9203	26.00-182.00 Ek SHLE GYWK Shale, psammitic, graphitic, pyritic, grey-black, minor greywacke at top, arenite below 150m; pyrrhot
KR9204	24.00-28.00 Tym SAND LMST Sand, quartzose, calcareous, minor limestone, fine grained, pale grey-yellow.
KR9207	56.00-182.00 Ek GYWK SCHT Quartz-muscovite-biotite+/-felspar+/-graphite greywacke & schist, minor interbeds of arenite, siltsto
MB 59	
MB 66	

Hole name	Unit 5	Unit 6
STRATH SILO 1		
81MBR 70		
81MBR 71	104.00-104.20 ?EOde GRNT Granite.	
81MBR 72	107.80-138.40 Tr SILT SAND Clay, brown, slightly silty, over silt & sand, medium-coarse grained, light brown, compact.	138.40-139.90 Ek ?SCHT Moderately strong rock, slightly schistose.
82MB12RM 1		
PD85HA 1		
81WCP 1		
81RVP 1		
81WCP 2		
STRATH BRIDGE 1		
STRATH BRIDGE 6		
STRATH BRIDGE 13		
BREMER G		
MC 56		
MC 96		
BREMER E		
MC 87		
MC 88		
DM3	365.00-420.00 ?Teob LMST SAND Limestone, sub-angular calcite & quartz, medium grained, fossiliferous, silty, glauconitic, musta	
DM4	112.78-118.87 ?CP-j CLYU Clay, stiff, non-calcareous, yellow/brown-light brown.	118.87-122.53 Ek CLYU SLAT Blue-green clay over blue-grey slate.
82LC3P 1		
80HRM 1		
80HRM 2		
80HRM 3		
80HRM 4		
80HRM 11	86.00-112.00 Tr CLYU SILC CARBONACEOUS CLAY,FOSSILIFEROUS SILCRETE	112.00-114.00 Ek GYWK MICACEOUS METAGREYWACKE
80HRM 5		
80HRM 7		
80HRM 6		
80HRM 8		
80HRM 9		
80HRM 10		
80HRM 12	46.00-50.00 Tome MARL MARLS	50.00-56.00 Tr CLYU CARBONACEOUS CLAY
LK 1		
KR9201		
KR9202	60.00-140.00 Ek SDST SHLE Interbedded arenite, shale & greywacke, schistose, minor siltstone & quartzite; pyritic throughout to	
KR9203		
KR9204	28.00-178.00 Ek GYWK SCHT Quartz-biotite greywacke, dark grey, several bands of quartz-graphite-pyrrhotite schist; pyrrhotite t	
KR9207		
MB 59		
MB 66		

Hole name	Unit 7	Unit 8
STRATH SILO 1		
81MBR 70		
81MBR 71		
81MBR 72		
82MB12RM 1		
PD85HA 1		
81WCP 1		
81RVP 1		
81WCP 2		
STRATH BRIDGE 1		
STRATH BRIDGE 6		
STRATH BRIDGE 13		
BREMER G		
MC 56		
MC 96		
BREMER E		
MC 87		
MC 88		
DM3		
DM4		
82LC3P 1		
80HRM 1		
80HRM 2		
80HRM 3		
80HRM 4		
80HRM 11		
80HRM 5		
80HRM 7		
80HRM 6		
80HRM 8		
80HRM 9		
80HRM 10		
80HRM 12	56.00-82.00 Teob LMST CLYU GLAUCONITIC LIMESTONE, FOSSILIFEROUS, CARBONACEOUS INTERBEDS.	82.00-84.00 Ek GYWK METAGREYWACKE
LK 1		
KR9201		
KR9202		
KR9203		
KR9204		
KR9207		
MB 59		
MB 66		

APPENDIX 6

MINERAL EXPLORATION DRILL HOLES, DOWNLOADED FROM PIRSA WEBSITE

These data include information on the drillholes and sources of data for mineral exploration drillholes that have geological information in Appendices 4, 5 and 8. The data are selected from a dataset downloaded from the PIRSA website in late 2002.

DH name	Lease	Hole id	Easting	Northing	Dip	Azimuth	Max Depth	Core Lib	Operator	Reference	Reference notes
STRATH SILO 1		6627-1128	308650	6096244	-90.0		17.83	N	DME.	RB55/00134	Appendix 1
81MBR 70	EL00547	6627-8147	315522	6095078	-90.0		26.40	Y	CRA	ENV03729	pp 365,366, 386
81MBR 71	EL00547	6627-8148	309307	6082578	-90.0		104.20	Y	CRA	ENV03729	pp 368-371,387
81MBR 72	EL00547	6627-8149	310922	6080478	-90.0		139.90	Y	CRA	ENV03729	pp 373-376, 388
82MB12RM 1	EL00964	6627-8161	312442	6093358	-90.0		26.50	N	CRA	ENV03729	page 721
PD85HA 1	EL01280	6627-8953	313127	6096353	-60.0	270.00	94.00	N	CRA	ENV06188	page 118
81WCP 1	EL00612	6627-9017	314112	6104423	-60.0	112.00	142.00	Y	CRA	ENV03832	pp 103, 104
81RVP 1	EL00612	6627-9018	309972	6101626	-60.0	270.00	70.00	Y	CRA	ENV03832	page 105
81WCP 2	EL00612	6627-9019	314167	6104628	-60.0	112.00	182.00	Y	CRA	ENV03832	pp 101, 102
STRATH BRIDGE 1		6627-9133	308197	6096903	-90.0		4.57	N	DME	RB49/00156	Appendix
STRATH BRIDGE 6		6627-9134	308072	6096838	-90.0		8.38	N	DME	RB49/00156	Appendix
STRATH BRIDGE 13		6627-9135	308127	6096863	-90.0		4.88	N	DME	RB49/00156	Appendix
BREMER G		6727-276	320402	6109703	-90.0		15.54	N	DME	RB28/00101	page 2
MC 56		6727-539	321144	6104824	-90.0		3.00	Y	DME.	RB75/00011	Appendix 1
MC 96		6727-541	326113	6107380	-90.0		17.40	Y	DME.	RB76/00091	
BREMER E		6727-659	320409	6109737	-90.0		5.79	N	DME.	RB28/00101	page 3
MC 87		6727-723	322172	6109744	-90.0		12.50	Y	DME.	RB76/00091	Appendix 1
MC 88		6727-724	322316	6110037	-90.0		20.40	Y	DME.	RB76/00091	Appendix 1
DM3		6727-1529	323015	6084508	-90.0		128.02	Y	DME.		
DM4		6727-1867	321816	6092544	-90.0		122.53	N	DME.		
82LC3P 1	EL00964	6727-2346	324647	6097178	-90.0		64.00	N	CRA	ENV03729	page 719
80HRM 1	EL00547	6727-2358	321542	6101628	-90.0		34.00	Y	CRA	ENV03729	3729(2)-8
80HRM 2	EL00547	6727-2359	321472	6100878	-90.0		32.00	Y	CRA	ENV03729	3729(2)-9
80HRM 3	EL00547	6727-2360	321422	6099828	-90.0		32.00	N	CRA	ENV03729	3729(2)-10
80HRM 4	EL00547	6727-2361	321372	6098428	-90.0		84.00	Y	CRA	ENV03729	3729(2)-11
80HRM 11	EL00547	6727-2362	321172	6101678	-90.0		114.00	Y	CRA	ENV03729	page 143, 157-159
80HRM 5	EL00547	6727-2363	321292	6096368	-90.0		78.00	Y	CRA	ENV03729	3729(2)-13
80HRM 7	EL00547	6727-2364	321942	6096078	-90.0		108.00	Y	CRA	ENV03729	3729(2)-18
80HRM 6	EL00547	6727-2365	322962	6095638	-90.0		110.00	Y	CRA	ENV03729	3729(2)-15
80HRM 8	EL00547	6727-2366	323102	6094478	-90.0		124.00	Y	CRA	ENV03729	3729(2)-21
80HRM 9	EL00547	6727-2367	322892	6092278	-90.0		129.00	Y	CRA	ENV03729	3729(2)-24
80HRM 10	EL00547	6727-2368	323172	6090498	-90.0		130.00	Y	CRA	ENV03729	3729(2)-27
80HRM 12	EL00547	6727-2369	321291	6103737	-90.0		84.00	Y	CRA	ENV03729	page 144, pp 160-161
LK 1	SML00430	6727-2515	319832	6097183	-80.0	270.00	88.85	Y	North Broken Hill	ENV01425	page 34
KR9201	EL01733	6727-2516	322812	6104198	-90.0		98.00	Y	BHP	ENV08499	pp 408-414
KR9202	EL01733	6727-2517	329722	6097778	-90.0		140.00	Y	BHP	ENV08499	pp 414-423
KR9203	EL01733	6727-2518	328662	6100118	-70.0	263.00	182.00	Y	BHP	ENV08499	pp 423-434
KR9204	EL01733	6727-2519	327382	6101178	-70.0	23.00	182.00	Y	BHP	ENV08499	pp 434-446
KR9207	EL01733	6727-2522	325172	6099578	-70.0	263.00	182.00	Y	BHP	ENV08499	pp 470-481
MB 50	EL01733	6727-2579	330802	6097978	-90.0		9.00	N	BHP	ENV08499	pp 174-389
MB 51	EL01733	6727-2580	329922	6098418	-90.0		25.00	N	BHP	ENV08499	pp 174-389
MB 52	EL01733	6727-2581	328852	6098958	-90.0		22.00	N	BHP	ENV08499	pp 174-389
MB 53	EL01733	6727-2582	327842	6099488	-90.0		18.00	N	BHP	ENV08499	pp 174-389
MB 54	EL01733	6727-2583	326992	6100258	-90.0		20.00	N	BHP	ENV08499	pp 174-389

DH name	Lease	Hole id	Easting	Northing	Dip	Azimuth	Max Depth	Core Lib	Operator	Reference	Reference notes
MB 55	EL01733	6727-2584	326262	6100908	-90.0		27.00	N	BHP	ENV08499	pp 174-389
MB 56	EL01733	6727-2585	325302	6101288	-90.0		30.00	N	BHP	ENV08499	pp 174-389
MB 57	EL01733	6727-2586	324192	6101368	-90.0		15.00	N	BHP	ENV08499	pp 174-389
MB 58	EL01733	6727-2587	323232	6101558	-90.0		21.00	N	BHP	ENV08499	pp 174-389
MB 59	EL01733	6727-2588	322162	6101978	-90.0		23.00	N	BHP	ENV08499	pp 174-389
MB 60	EL01733	6727-2589	321232	6102378	-90.0		13.00	N	BHP	ENV08499	pp 174-389
MB 61	EL01733	6727-2590	326692	6098878	-90.0		20.00	N	BHP	ENV08499	pp 174-389
MB 62	EL01733	6727-2591	325702	6098878	-90.0		27.00	N	BHP	ENV08499	pp 174-389
MB 63	EL01733	6727-2592	324722	6099078	-90.0		44.00	N	BHP	ENV08499	pp 174-389
MB 64	EL01733	6727-2593	323692	6099258	-90.0		27.00	N	BHP	ENV08499	pp 174-389
MB 65	EL01733	6727-2594	322492	6099278	-90.0		26.00	N	BHP	ENV08499	pp 174-389
MB 66	EL01733	6727-2595	321422	6099298	-90.0		20.00	N	BHP	ENV08499	pp 174-389
MB 67	EL01733	6727-2596	330022	6097578	-90.0		18.00	N	BHP	ENV08499	pp 174-389
MB 68	EL01733	6727-2597	330022	6096438	-90.0		12.00	N	BHP	ENV08499	pp 174-389
MB 69	EL01733	6727-2598	330122	6095558	-90.0		24.00	N	BHP	ENV08499	pp 174-389
MB 70	EL01733	6727-2599	330112	6094458	-90.0		18.00	N	BHP	ENV08499	pp 174-389
MB 71	EL01733	6727-2600	330122	6093378	-90.0		15.00	N	BHP	ENV08499	pp 174-389
MB 72	EL01733	6727-2601	330202	6092368	-90.0		18.00	N	BHP	ENV08499	pp 174-389

APPENDIX 7

SUMMARIES OF DRILLER'S LOGS

The data presented are summaries made by the author of the drillers logs (and in a few cases, geologists logs) of water bores, held as microfiche at the Department of Water, Land and Biodiversity Conservation in Adelaide. The table includes information that is pertinent to the current study from water bores that are not included in Appendices 3 and 4. The depths for hole 6627-7089 assume that the depths recorded on the driller's log are in feet, although this is not stated on the log. The elevations of some important holes have been estimated by intersecting the hole location with the radar DEM.

Hole id	Easting	Northing	Elevation	Depth (m)	Brief lithology
6627-860	309032	6089282		0-30.5	Limestone, clay and sand
				30.5-33.5	Bed rock
6627-915	316155	6092091		0-0.3	Soil
				0.3-6.1	Clay
				6.1-22	Sandy clay
				22-23.4	Gravel and clay (with maghemite and staurolite)
6627-968	313088	6090285		0-38.4	Mainly sand
				38.4-39.0	Green limestone
6627-983	311805	6090929		66.4 TD	'Sands at bottom with silt probably of Permian age'
6627-1001	307072	6091315	64.62	0-3.2	Soil and sandy marl
				3.2-25.3	Brown and grey sandy clay
				25.3-30.8	Sandstone, clay, grit and fossiliferous limestone
				30.8-	Basement
6627-1013	307598	6092316		0-5.2	Grey brown silty mica clay
				5.2-9.0	Yellow grey fine sandy clay
				9.0-9.8	Grey brown sandy clay
				9.8-9.8	Sand and pebbles
				9.8-11.6	Brown slightly micaceous sandy clay
				11.6-15.8	Grey and yellow sandy clay
				15.8-17.7	Greyish yellow medium coarse sand
				17.7-19.8	? beach sand
				19.8-26.2	Greenish grey micaceous sandy clay (bedrock derived?)
				26.2-30.5	Grey silty fine sandy clay
				30.5-36.6	Grey silty fine sandy clay with fragments of sandy slate
				36.6-40.8	Grey slate
6627-1141	312254	6096521		0-2.4	Soil and subsoil
				2.4-5.5	'red sandy calcareous'
				5.5-10.7	Greenish brown micaceous clay (decomposed phyllite?)
				10.7-	Schist and phyllite
6627-1145	313302	6096993		0-0.9	Soil and subsoil
				0.9-18.3	Decomposed phyllite
				18.3-	Phyllite and schist
6627-1147	313691	6097024		0-1.5	sand and limestone
				1.5-4.0	yellow clay
				4.0-14.6	red clay and red sandstone
				14.6-17.1	yellow clay
				17.1-	Slate and 'hard grey rock'
6627-1151	314318	6094360		0-0.6	Surface soil
				0.6-11.0	Red clay
				11.0-	'Bluestone' and slate
6627-1152	314243	6094368		0-0.6	Surface soil
				0.6-2.4	Red clay
				2.4-	'Bluestone', shale, slate
6627-1158	314769	6096314		0-9.1	Clay
				9.1-11.6	Yellow clay
				11.6-	'bluerock', slate, quartzite etc
6627-5774	311659	6097668	82.1	0-1.2	Clay
				1.2-1.5	Limestone
				1.5-13.7	Sandy gravel
				13.7-19.8	Yellow sand
				19.8-22.9	White sand

Hole id	Easting	Northing	Elevation	Depth (m)	Brief lithology
				22.9-26.5	Coarse gravel
				26.5-30.2	Soft slate
6627-5792	312761	6099968		0-8	'top soil red clay and various coloured mudstone'
				8-	Mudstone, schist, slate etc
6627-5795	314113	6099262	90.01	0-1.8	Soil
				1.8-6.1	Sandy loam
				6.1-18.3	"Soft blue rock"
				18.3-21.3	"Hard bluestone"
6627-5808	310978	6100619		0-0.9	Surface soil
				0.9-8.5	Sandy clay
				8.5-9.8	Gravel
				9.8-	Basement lithologies
6627-6051	310850	6101613		0-4	'soil and soft grey rock'
				4-	Basement lithologies
6627-6543	310752	6102042		0-1.5	Topsoil, clay
				1.5-	Schist
6627-6546	311725	6100415		0-0.4	Clay
				0.4-2	White limestone
				2-2.5	Grey brown sandstone
				2.5-	Schist
6627-6628	305512	6091227	82.02	0-1.7	Clay
				1.7-2	Soft grey rock
				2-	Hard grey rock
6627-6837	304956	6087510	61.72	0-0.5	Soil
				0.5-3	Brown shale
				3-6	Grey shale
				6-12	Dark grey shale
				12-	Basement lithologies
6627-6838	305203	6086091		0-39	Red, tan, brown and grey sandy clay
				39-48	Clay and gravel
				48-68	"Blue rock"
6627-6841	305877	6091037	75.50	0-1	Sandy topsoil
				1-3	Brown clay
				3-5	Soft slate
				5-	Hard slate
6627-6979	308661	6091383	47.56	0-23	Clay
				23-24	Sand
				24-32	Coral limestone
6627-7089	309176	6090163		0-4.0	Brown clay
				4.0-4.6	Sand
				4.6-10.7	Clay and sandstone seams
				10.7-21.3	Mudstone and sandstone
				21.3-23.8	White clay and quartz
				23.8-25.3	Soft sandstone
				25.3-27.7	Harder mudstone and sandstone seams
6627-7206	311596	6088006	38.48	0-2	Sand and sandy clay
				2-24	Red mottled and light grey brown clay
				24-26.5	Limestone and sandstone
				26.5-28.8	Sand
				28.8-35	Sandstone and limestone with glauconite
6627-7235	308636	6093864	57.46	0-0.3	Red clay
				0.3-7.3	Brown clay with small amounts of limestone

Hole id	Easting	Northing	Elevation	Depth (m)	Brief lithology
				7.3-13.7	Soft grey schist
6627-7388	36255	6093715		0-11	Red clay
				11-11.3	Red clay and gravel
				11.3-18	Red clay
				18-25	Red sand and gravel
6627-7439	316058	6094084	25.38	0-16.5	Red clay
				16.5-17	Sand and gravel
				17-25	"Shaley rock"
6627-7447	316145	6092256		0-22	Clay
				22-26	Gravel
				26-31.6	Clay
6627-7659	315486	6094108	30.99	0-1	Limestone
				1-4.3	Red sand
				4.3-10	Yellow red clay and gravel
				10-35	Yellow red clay
				35-39.9	"Brown shale and water" (ie basement)
6627-7760	316185	6096622	33.97	0-2.1	Brown tough clay
				2.1-3.6	Sandy brown clay
				3.6	Hard brown schist and other basement lithologies
6627-8272	306353	6090821	69.87	0-7	Clay
				7-12	Sandstone
				12-20	Soft mica schist
				20-79	Basement lithologies
6627-8284	316887	6098273	36.36	0-2	Soil
				2-10	Brown silty sand
				10-12	Green clay
				12-14	Blue clay
				14-	"Hard rock"
6627-8279	312300	6101235		0-3.6	Sandy topsoil, clay
				3.6-	Schist
6627-8654	305563	6088152	54.46	0-12.8	Mudstone, sandstone
				12.8-17.3	Sandstone
				17.3-54	"Shistone"
6627-8889	315166	6100643	102.83	0-6	"Shaley clay"
				6-	"Hard bluestone" and other basement lithologies
6627-8890	314646	6101028	78.90	0-6	Clay
				6-20	"Weathered bluestone"
				20-	Hard bluestone and other basement lithologies
6627-9167	312216	6086618	29.69	0-3	No record
				3-6	Sand
				6-21	Clay
				21-24	Limestone
				24-30	Sandstone
				30-54	Sandstone and limestone
				54-59	Limestone
				59-60	Clay
				60-63	Sand and clay
				63-69	Clay
				69-75	Gravel
				75-96	Clay
				96-100.5	Schist

Hole id	Easting	Northing	Elevation	Depth (m)	Brief lithology
6627-9168	312241	6086748	30.20	0-3	Sand (NB logged by S. Howles)
				3-15	Clay
				15-18	Sand
				18-57	Sandstone and limestone
				57-57.3	Clay
6627-9169	312256	6086538	29.40	0-3	No record (NB logged by S. Howles)
				3-18	Clay
				18-21	No sample
				21-57.3	Sandstone and limestone
				57.3-58.3	Sandy clay
6627-9627	316911	6097888	33.76	0-18	Red loam
				18-22	Shaley gravel
				22-49	"Blue rock with fractures"
6627-10022	315271	6089838	23.33	0-1	Soil
				1-3	Sandy clay
				3-18	Clay
				18-50	Silty sand
				At 50	Lignite
6627-10626	304483	6084859		0-4	White and brown clay
				4-32	Brown and grey sandy clay
				32-48	Yellow white clayey sand and grey clay layers
				48-49	"Weathered rock"
				49-142	"Hard blue rock"
6627-10635	306641	6088992	48.27	0-1	Soil
				1-17	Orange and red clay
				17-20	Sandy yellow clay
				20-25	Soft white sandstone
				25-29	Soft grey schist
				29-37	Harder grey schist
				37-	Basement lithologies
6627-10683	314902	6101545	71.45	0-2	Soil
				2-8	Weathered grey slate/soil
				8-	Slate and other basement lithologies
6627-10726	306364	6089440	54.37	0-15	Stiff red clay
				15-17	Softer clay
				17-19	Shale
				19-	Soft grey schist and other basement lithologies
6727-1381	324567	6102608	57.48	0-.5	Sandy red soil
				.5-18	Clay and limestone
				18	Finished in mica schist at 18 m
6727-1405	319643	6100201	56.91	0-2.74	Stiff brown clay
				2.74-19.81	Yellow sandy clay
				19.81-24.38	Black clay
				24.38-32.92	Dark clay mud
				32.92-33.83	Yellow sand
				33.83-56.39	Dark clay mud
				56.39-67.06	Blue shale with trace of quartz
6727-1458	321885	6106853	103.16	0-0.5	Top soil
				0.5-3	Orange sandy clay
				3-6	White clay
				6-30	Red sand clay
				30-78	Hard and soft limestone
				78-90	Soft blue slate

Hole id	Easting	Northing	Elevation	Depth (m)	Brief lithology
6727-1633	322538	6106285	86.61	0-1.5	Limestone
				1.5-10	Soapstone, sticky, clay
				10-16.1	Foram limestone, sandstone
				16.1-19.2	Soft yellow sand
				19.2-34.1	Limestone and sandstone
				34.1-53.9	Soft dry sand
				53.9-58.5	Mudstone and gravel
				58.5-69.7	Black mudstone, shale, clean quartz
				69.7-81.3	Blue shaley slate
6727-2172	320152	6103690	66.72	0-0.6	White limestone
				0.6-6	Brown clay
				6-7	Brown mudstone
				7-10	Sand and quartz
				10-13	Sand and clay
				13-18	Mudstone and sandstone
				18-21	Clay, mudstone and sandstone
				21-34	Brown schisty mudstone
				34-53	Kanmantoo schist
6727-2288	318296	6104015	52.94	0-11.9	Sand and gravel
				11.9-	Schist
6727-2419	318721	6103028	51.33	0-2	Limestone
				2-6	Sandy clay
				6-7	Schisty formation, clay
				7-9	Gravel bed, quartz
				9-11	Sandy sandstone
				11-12	Shaley clay
				12-13.5	Shaley grey schist rock
6727-2879	320337	6104215	71.00	0-7	Limestone then sand
				7-14	Limestone sand zones
				14-21	Mostly limestone, clay
				21-28	Limestone cavernous
				28-42	Limestone sandy clays cavernous
				42-49	Cavernous limestone with water
				49-56	Clay, rubbly limestone into softer mica schist
				56-84	Schist
6727-2910	319379	6104173	54.71	0-1.5	Red sandy soil and calcrete
				1.5-6	Clay
				6-12	Sandy clay
				12-18	River silt and gravels
				18-44	Schist and slate, weathered yellow in top 6 m

APPENDIX 8

LOGS OF MINERAL SANDS EXPLORATION HOLES

These holes were drilled by BHP Minerals in the north of the study area, in an area with few other drill holes. They are included in Appendix 5, but there is no geological information available from the web. However, logs are available in open file envelope 8499 at PIRSA. These holes give important information on the depth to Miocene limestone and basement. The following data are summarised by the author from the open file envelope.

Locations as shown in the drill hole database (Appendix 5) are included in the table. Elevations have been estimated by intersecting the locations with the magspec DEM.

Hole	Hole id	Easting	Northing	Elev	Depth	Lithology
MB49	6727-2578	331742	6097678		0-3	Calcrete and calcareous quartz sand
					3-4	Well sorted fine quart sand
					4-6	fine sandy clay
					6-12	fine quartz sand, soft
					12-15	fine sandy clay
					15	limestone (bottom of hole)
MB50	6727-2579	330802	6097978		0-2	calcrete
					2-8	stiff clay
					8-9	micaceous sandstone (weathered basement)
MB51	6727-2580	329922	6098418	27.17	0-2	calcrete
					2-4	calcareous clay and calcrete
					4-8	stiff clay
					8-10	clay and fine poorly sorted quartz sand
					10-12	Very fine to fine well sorted quartz sand and clay
					12-16	sandy clay, sand very fine, moderately well sorted
					16-25	quartz sand, very fine to medium, well sorted, bottomed on limestone
MB52	6727-2581	328852	6098958	35.49	0-2	calcrete
					2-4	calcareous quartz sand
					4-10	clayey well sorted fine quartz sand
					10-20	fine well sorted quartz sand
					20-22	medium quartz sand, bottomed on limestone
MB53	6727-2582	327842	6099488	40.47	0-2	calcrete
					2-4	clayey fine quartz sand and calcrete
					4-10	well sorted fine quartz sand
					10-12	clayey well sorted fine sand
					12-14	very fine to fine well sorted quartz sand
					14-16	Very fine to fine calcareous quartz sand, well sorted
					16-18	limestone and calcareous sand
MB54	6727-2583	326992	6100258	60.31	0-2	calcrete
					2-4	fine sandy calcrete
					4-6	clayey fine well sorted sand
					6-16	fine well sorted quartz sand
					16-18	clayey fine moderately sorted quartz sand
					18-20	fine well sorted quartz sand, bottomed on schist
MB55	6727-2584	326262	6100908	86.04	0-2	Calcareous quartz sand, fine well sorted
					2-4	fine sandy calcrete
					4-26	very fine, fine and medium quartz sand, well sorted
					26-27	schist
MB56	6727-2585	325302	6101288	77.19	0-2	calcrete
					2-4	calcareous sandy clay, calcrete
					4-6	calcareous fine sandy clay
					6-8	well sorted fine to medium sand
					8-18	well sorted fine sand
					18-30	clayey fine quartz sand. Bottomed on limestone
MB57	6727-2586	324192	6101368	73.39	0-2	Calcrete
					2-6	Calcareous fine quartz sand
					6-15	fine to medium well sorted quartz sand. Bottomed on limestone
MB58	6727-2587	323232	6101558	67.40	0-4	Calcrete
					4-8	Poorly sorted fine sandy clay
					8-12	clayey fine well sorted quartz sand
					12-16	calcareous fine well sorted quartz sand
					16-18	fine well sorted quartz sand
					18-21	calcareous fine moderately well sorted quartz sandstone,

Hole	Hole id	Easting	Northing	Elev	Depth	Lithology
						bottomed in limestone
MB59	6727-2588	322162	6101978	55.53	0-2	fine to medium well sorted quartz sand
					2-4	fine to medium poorly sorted quartz sand and calcrete
					4-6	clayey calcareous poorly sorted quartz sand
					6-14	clayey fine well sorted quartz sand
					14-22	calcareous fine to medium well sorted weakly consolidated quartz sandstone
					22-23	limestone
MB60	6727-2589	321232	6102378	49.44	0-2	calcareous fine moderately well sorted quartz sand
					2-8	fine well sorted quartz sand
					8-12	fine sandy calcareous clay
					12-13	sandy calcareous caly and limestone
MB61	6727-2590	326692	6098878	35.55	0-2	calcrete
					2-4	calcareous clay
					4-6	fine poorly sorted sandy clay
					6-10	clayey fine well sorted quartz sand
					10-12	fine well sorted quartz sand
					12-14	calcareous fine well sorted quartz sand
					14-18	fine calcareous quartz sand and limestone
					18-20	schist, weathered
MB62	6727-2591	325702	6098878	68.22	0-4	calcareous fine poorly sorted sand
					4-8	clayey poorly sorted fine quartz sand
					8-26	fine and minor medium quartz sand, well sorted
					26-27	limestone
MB63	6727-2592	324722	6099078	69.22	0-2	very fine to fine well sorted quartz sand
					2-4	calcareous very fine to fine poorly sorted quartz sand, calcrete
					4-6	calcareous clayey fine poorly sorted quartz sand
					6-8	calcareous clay
					8-10	clay
					10-14	clayey fine moderately well sorted fine quartz sand
					14-36	fine well sorted quartz sand
					36-44	calcareous well sorted fine sand, bottomed on limestone
MB64	6727-2593	323692	6099258	53.30	0-2	calcareous fine sandy clay
					2-4	fine sandy clay
					4-24	fine and minor medium well sorted quartz sand
					24-27	very fine to fine well sorted calcareous quartz sand and weakly consolidated sandstone
MB65	6727-2594	322492	6099278	43.98	0-2	calcrete
					2-4	calcareous clayey fine poorly sorted quartz sand
					4-6	fine poorly sorted sandy calcareous clay
					6-16	fine to medium well sorted quartz sand
					16-18	calcareous fine to medium well sorted quartz sand
					18-26	calcareous well sorted to moderately well sorted quartz sand and sandstone. Sponge spicules 18-20
MB66	6727-2595	321422	6099298	28.63	0-8	very fine sandy silt with mica
					10-16	fine to medium well sorted quartz sand
					16-20	calcareous fine to medium grained weakly consolidated quartz sandstone
MB67	6727-2596	330022	6097578	17.52	0-2	calcrete and sand
					2-6	silt to fine sand, poorly sorted, with mica
					6-10	poorly sorted clay to fine sand
					10-12	well sorted fine to medium sand
					12-16	calcareous well sorted very fine quartz sand
					16-18	calcareous well sorted very fine to fine quartzose sand

Hole	Hole id	Easting	Northing	Elev	Depth	Lithology
MB68	6727-2597	330022	6096438	10.42	0-2	calcareous fine sandy clay
					2-6	fine sandy clay
					6-8	sandy silt (with mica)
					8-10	clayey fine quartz sand, moderately well sorted
					10-12	calcareous fine well sorted quartz sandstone
MB69	6727-2598	330122	6095558	13.64	0-2	calcrete
					2-18	very fine poorly sorted sandy silt with mica
					18-20	sandy clay
					20-22	fine well sorted quartz sand
					22-24	calcareous very fine well sorted quartz sand
MB70	6727-2599	330112	6094458	14.56	0-6	very fine sandy silt with mica
					6-8	fine to medium well sorted quartz sand
					8-12	fine sandy silt with mica
					12-16	fine well sorted quartz sand
					16-18	limestone, fossiliferous
MB71	6727-2600	330122	6093378	7.71	0-2	calcareous fine sandy silt
					2-4	fine sandy silt
					4-8	fine sandy clay with mica
					8-10	clay
					10-12	fine sandy clay
					12-14	very fine to fine well sorted quartz sand
					14-15	calcareous fine well sorted quartz sand and sandstone
MB72	6727-2601	330202	6092368	8.17	0-2	calcareous fine moderately well sorted sand
					2-4	calcareous fine sandy clay
					4-6	fine well sorted sandy clay
					6-8	very fine to fine well sorted quartz sand
					8-12	very fine sandy silt with mica
					12-16	fine well sorted quartz sand
					16-18	very fine well sorted calcareous quartz sand and sandy limestone

APPENDIX 9

DEPTH AND ELEVATION OF BASEMENT/CAINOZOIC CONTACT IN DRILLHOLES, WITH CDI CONDUCTIVITY AT CONTACT

This table is a distillation of the geological depth data for holes that penetrated through sediment into basement in the previous tables, combined with elevation of the drill hole (as determined from the magspec DEM) and the gridded CDI conductivity (from depth slices) at the basement/sediment contact. The conductivity data helped to determine locations of the structure contours of the base of the Cainozoic sediments. Note that the base Q for 6727-2238 is taken at 16 m (marked with an asterisk, see Lablack 1991), not 48 m as given on the web. Telfer *et al*. (2000) suggest in their figure 3 that hole 6727-1451 intersected basement at ~62 m, and was drilled to 85 m depth. SA web data show that 85 m is the correct total depth, but that the hole bottomed in Tertiary sediment. Therefore this hole is not included in this table.

The data are plotted in Figure 15 and the wide scatter implies that no single value of conductivity can be used to approximate the sediment/basement contact throughout the study area.

Hole id	Easting	Northing	Depth base Q	Depth top basement	Elev collar	Elev base Q	Elev top basement	CDI depth interval used	CDI (mS/m)
6627-864	312114	6086970	23.00	69.50	29.53	6.53	-39.97	65-70	104
6627-922	316965	6090351	41.15	114.30	21.51	-19.64	-92.79	110-115	54
6627-953	315387	6091332	32.00	32.00	25.70	-6.30	-6.30	30-35	19
6627-961	314278	6091947	25.00	25.00	31.47	6.47	6.47	Av 20-25 & 25-30	57
6627-973	313607	6092463	23.00	23.00	32.36	9.36	9.36	20-25	54
6627-1001	307072	6091315	25.30	30.80	64.62	39.32	33.82	25-30	30
6627-1170	317842	6096724	25.00	25.00	27.63	2.63	2.63	Av 20-25 & 25-30	124
6627-5774	311659	6097668		26.50	82.1		55.6	25-30	161
6627-5996	317947	6097339	52.00	52.00	30.39	-21.61	-21.61	50-55	9
6627-6692	317902	6096646	28.00	28.00	27.02	-0.98	-0.98	25-30	110
6627-6783	317740	6097479	53.00	53.00	30.31	-22.69	-22.69	50-55	11
6627-7198	312840	6084681	18.00	114.00	15.61	-2.39	-98.39	110-115	89
6627-7439	316058	6094084	17.00	17.00	25.38	8.38	8.38	15-20	84
6627-7445	315434	6092552	27.00	27.00	27.30	0.30	0.30	25-30	45
6627-7446	315499	6092444	23.00	23.00	26.53	3.53	3.53	20-25	115
6627-7659	315486	6094108	35.00	35.00	30.99	-4.01	-4.01	Av 30-35 & 35-40	17
6627-8147	315522	6095078	26.20	26.20	35.27	9.07	9.07	25-30	37
6627-8157	317672	6097468	57.00	57.00	30.65	-26.35	-26.35	55-60	11
6627-8161	312442	6093358	14.00	14.00	41.77	27.77	27.77	10-15	70
6627-8268	315347	6091148	34.00	34.00	27.10	-6.90	-6.90	30-35	24
6627-8272	306353	6090821	12.00	12.00	69.87	57.87	57.87	10-15	26
6627-8284	316887	6098273	10.00	10.00	36.36	26.36	26.36	Av 5-10 & 10-15	14
6627-8654	305563	6088152	17.30	17.30	54.46	37.16	37.16	15-20	14
6627-8696	316312	6091948	50.00	50.00	23.35	-26.65	-26.65	Av 45-50 & 50-55	129
6627-9167	312216	6086618	21.00	96.00	29.69	8.69	-66.31	95-100	49
6627-9627	316911	6097888	22.00	22.00	33.76	11.76	11.76	20-25	34
6627-10635	306641	6088992	25.00	25.00	48.27	23.27	23.27	Av 20-25 & 25-30	71
6627-10726	306364	6089440	17.00	17.00	54.37	37.37	37.37	15-20	107
6727-276	320402	6109703	12.19	12.19	65.91	53.72	53.72	10-15	7
6727-1381	324567	6102608	0.00	18.00	57.48	57.48	39.48	15-20	101
6727-1405	319643	6100201	2.74	56.39	56.91	54.17	0.52	55-60	110
6727-1458	321885	6106853	30.00	78.00	103.16	73.16	25.16	75-80	32
6727-1470	329003	6090292	17.10	115.20	5.54	-11.56	-109.66	115-120	102
6727-1505	329296	6085757	16.00	113.00	3.02	-12.98	-109.98	110-115	188
6727-1527	323227	6084473	28.30	136.00	5.88	-22.42	-130.12	135-140	35
6727-1529	323015	6084508	25.91	111.25	5.93	-19.98	-105.32	110-115	37
6727-1633	322538	6106285	10.00	69.70	86.61	76.61	16.91	65-70	53
6727-1704	322488	6089759	34.70	115.80	14.27	-20.43	-101.53	115-120	31)
6727-1867	321816	6092544	35.05	112.78	18.01	-17.04	-94.77	110-115	36
6727-1888	318465	6095017	32.50	68.00	25.89	-6.61	-42.11	65-70	23
6727-2172	320152	6103690	18.00	34.00	66.72	48.72	32.72	30-35	40
6727-2238	332264	6094238	16*	74.60	11.25	-36.75	-63.35	70-75	91
6727-2241	324137	6094826	34.00	71.00	28.21	-5.79	-42.79	70-75	67
6727-2243	319095	6094051	36.00	98.40	23.38	-12.62	-75.02	95-100	25
6727-2266	322334	6086943	25.00	120.00	9.20	-15.80	-110.80	Av 115-120 & 120-125	31
6727-2288	318926	6104015	12.00	12.00	52.94	40.94	40.94	10-15	50
6727-2346	324647	6097178	22.00	30.00	29.97	7.97	-0.03	Av 25-30 & 30-35	49
6727-2361	321372	6098428	24.00	66.00	23.28	-0.72	-42.72	65-66	104
6727-2362	321172	6101678	36.00	112.00	59.24	23.24	-52.76	110-115	17
6727-2363	321292	6096368	30.00	76.00	29.94	-0.06	-46.06	75-80	132
6727-2364	321942	6096078	38.00	104.00	24.44	-13.56	-79.56	100-105	79

Hole id	Easting	Northing	Depth base Q	Depth top basement	Elev collar	Elev base Q	Elev top basement	CDI depth interval used	CDI (mS/m)
6727-2365	322962	6095638	28.00	106.00	20.71	-7.29	-85.29	105-110	101
6727-2366	323102	6094478	26.00	118.00	17.56	-8.44	-100.44	115-120	74
6727-2367	322892	6092278	32.00	118.00	15.83	-16.17	-102.17	115-120	29
6727-2368	323172	6090498	28.00	126.00	13.40	-14.60	-112.60	125-130	31
6727-2369	321291	6103737	24.00	82.00	60.88	36.88	-21.12	80-85	13
6727-2419	318721	6103028	12.00	12.00	51.33	39.33	39.33	10-15	18
6727-2515	319832	6097183	no data	81.40	29.66		-51.74	80-85	65
6727-2516	322812	6104198	4.00	84.00	71.82	67.82	-12.18	80-85	71
6727-2517	329722	6097778	18.00	60.00	13.21	-4.79	-46.79	Av 55-60 & 60-65	113
6727-2518	328662	6100118	9.40	24.43	34.48	25.08	10.05	20-25	166
6727-2519	327382	6101178	22.55	26.31	71.19	48.64	44.88	25-30	39
6727-2522	325172	6099578	22.55	56.62	90.11	67.56	33.49	55-60	17
6727-2583	326992	6100258	6.00	20.00	60.31	54.31	40.31	Av 15-20 & 20-25	138
6727-2584	326262	6100908	4.00	26.00	86.04	82.04	60.04	25-30	45
6727-2590	326692	6098878	10.00	18.00	35.55	25.55	17.55	15-20	148
6727-2833	318124	6097315	24.70	24.70	32.03	7.33	7.33	20-25	147
6727-2879	320337	6104215	7.00	53.00	71.00	64.00	18.00	50-55	21
6727-2910	319379	6104173	18.00	18.00	54.71	36.71	36.71	15-20	98
AB01	319444	6104653	21.30	21.30	54.76	33.46	33.46	20-25	106
AB02	307139	6088238	19.00	47.00	40.36	21.36	-6.64	45-50	35
AB03	308056	6087862	10.00	10.00	42.64	32.64	32.64	Av 5-10 & 10-15	63
AB04	308923	6087057	17.00	29.00	36.57	19.57	7.57	25-30	54
AB07	315133	6093929	11.00	11.00	32.86	21.86	21.86	10-15	466
AB08	316123	6094138	17.00	17.00	26.29	9.29	9.29	15-20	93

APPENDIX 10

DRILL HOLES WITH WIRELINE LOGS HELD AT DEPARTMENT OF WATER, LAND AND BIODIVERSITY CONSERVATION

Steve Barnett of the SA Department of Water, Land and Biodiversity Conservation provided this information.

The abbreviations used for log types are:

Cal	caliper
CCL	collar casing locator
D	density
DB	bulk density
DF	far density
DN	near density
G	gamma
N	neutron
PR	point resistivity
SP	self potential
TV	television

Casing types are either steel (STL) or PVC

Obs Well No	Hole id	Depth	Casing	Job no	Log type						
BRM3	6727-1964	42	STL	984	CAL	DB	CCL	G	N		
BRM33	6627-1224	32	PVC	3749	G	N					
BRM34	6627-1248	13	PVC	3750	G	N					
BRM35	6627-776	35	PVC	3751	G	N					
BRM36	6727-1610	32	PVC	3752	G	N					
BRM37	6727-1606	31	PVC	3753	G	N					
BRM38	6627-864	39	STL	332	CAL	G	N	D			
BRM49	6727-2373	68	STL	4486	CAL	CCL	G	N	DB		
BRM134	6727-1618	36	STL	1680	CAL	DF	DN				
BRM156	6627-7198	121	STL	311	G	N	SP	PR			
BRM159	6727-2266	149	STL	358	CAL	G	N	SP	PR	DN	DF
BRM201	6727-1970	5	PVC	3754	G	N					
BRM203	6727-1982	5	PVC	3755	G	N					
BRM204	6727-1989	17	PVC	3756	G	N					
BRM205	6727-2013	17	PVC	3757	G	N					
BRM206	6727-2005	14	PVC	3758	G	N					
BRM207	6727-1999	14	PVC	3759	G	N					
BRM208	6727-2038	6	PVC	3760	G	N					
BRM210	6727-2020	3	PVC	3761	G	N					
BRM211	6627-948	17	PVC	3762	G	N					
BRM212	6727-2035	17	PVC	3763	G	N					
BRM213	6727-2070	17	PVC	3764	G	N					
BRM214	6727-2081	17	PVC	3765	G	N					
BRM215	6727-2077	14	PVC	3766	G	N					
BRM216	6727-1658	14	STL	3767	G	N					
BRM217	6627-1254	14	PVC	3768	G	N					
BRM218	6627-1237	19	PVC	3769	G	N					
BRM219	6727-1659	14	STL	3770	G	N					
BRM220	6727-1672	13	PVC	3771	G	N					
BRM221	6627-1223	14	PVC	3772	G	N					
BRM222	6727-1607	11	STL	3773	G	N					
BRM223	6727-1596	5	PVC	3727	G	N					
BRM223	6727-1596	8	PVC	3774	G	N					
BRM224	6727-1611	5	PVC	3728	G	N					
BRM225	6727-2846	5	PVC	3729	G	N					
BRM226	6727-1595	5	STL	3730	G	N					
BRM227	6727-1594	4	STL	3731	G	N					
BRM229	6727-1597	5	PVC	3732	G	N					
BRM231	6627-1335	10	PVC	3733	G	N					
BRM232	6627-1249	12	PVC	3775	G	N					
BRM234	6627-917	23	PVC	3776	G	N					
BRM235	6627-1329	15	PVC	3734	G	N					
BRM236	6627-935	14	PVC	3777	G	N					
FRL62	6727-1679	36	PVC	3778	G	N					
FRL63	6727-1693	35	PVC	3779	G	N					
FRL64	6727-1736	33	PVC	3780	G	N					
FRL65	6727-1570	31	PVC	3781	G	N					
FRL66	6727-1470	57	PVC	3782	G	N					
FRL67	6727-1505	123	STL	3563	G	N					
FRL102	6727-1797	65	STL	4489	CAL	N	G	DB	CCL		
FRL102	6727-1797	65	STL	4490	TV						
FRL125	6727-1742	27	STL	1495	CAL	CCL	G	N	DB		
FRL138	6727-2241	71	STL	245	CAL	G	SP	PR	N	D	

Obs Well No	Hole id	Depth	Casing	Job no	Log type						
FRL143	6727-2238	73	PVC	240	CAL	DF	G	DN	SP	PR	N
FRL146	6727-1290	73	STL	4488	CAL	CCL	N	G	DB		
FRL162	6727-2281	54	STL	4487	CAL	CCL	DB	N	G		
FRL205	6727-1435	14	PVC	3783	G	N					
FRL207	6727-1701	5	PVC	3784	G	N					
FRL208	6727-1714	6	PVC	3785	G	N					
FRL209	6727-1504	5	PVC	3786	G	N					
FRL210	6727-1699	14	PVC	3787	G	N					
FRL211	6727-1764	12	PVC	3788	G	N					
FRL212	6727-1492	11	PVC	3789	G	N					
FRL216	6727-1737	15	PVC	3790	G	N					
FRL217	6727-1531	15	PVC	3791	G	N					
FRL218	6727-1552	14	PVC	3792	G	N					
FRL219	6727-1564	14	PVC	3793	G	N					
FRL220	6727-1517	10	PVC	3794	G	N					
FRL221	6727-1585	11	PVC	3795	G	N					
FRL222	6727-1824	17	PVC	3796	G	N					
FRL223	6727-1833	12	PVC	3797	G	N					
FRL224	6727-1694	10	PVC	3798	G	N					
FRL225	6727-1680	10	PVC	3799	G	N					
FRL226	6727-1476	12	PVC	3800	G	N					
FRL227	6727-1847	17	PVC	3801	G	N					
FRL228	6727-1506	9	PVC	3735	G	N					
STY108	6727-2243	105	STL	251	CAL	G	D	SP	PR	N	
STY201	6627-1167	18	STL	3803	G	N					
STY203	6627-1186	12	PVC	3805	G	N					
STY204	6627-1180	14	PVC	3806	G	N					
STY205	6727-1914	10	PVC	3807	G	N					
	6727-1964	42		984	CAL	CCL	DB	N	G		
	6727-1618	36		1680	CAL	DF	DN				
	6727-2373	68		4486	CAL	CCL	DB	N	G		
	6727-2281	54		4487	CAL	CCL	DB	N	G		
	6727-1290	73		4488	CAL	CCL	DB	N	G		
	6727-1797	65		4489	CAL	CCL	DB	N	G		
	6727-1797	65		4490	TV						

APPENDIX 11

GEOLOGICAL INTERPRETATION OF WATER BORES FROM BROWN & STEPHENSON (1986)

The following table summarises geological interpretation of drillers logs made by Brown & Stephenson (1986). Locations of the holes are as shown in SA databases rather than the locations given by Brown & Stephenson. Geological interpretations of all holes in this table are shown in other Appendices. The interpretations shown here have not been used in the current study, but are included for completeness.

Hole id	Easting	Northing	Depth	Unit
6727-1415	325872	6101283	0-2	Quaternary
(MC92)			2-25TD	Pliocene sand
6727-1445	331827	6091870	0-15	Quaternary dolomite
			15-23	Loxton-Parilla Sands
			23-25 TD	Murray Gp limestone
6727-1456	328343	6090504	0-17	Quaternary dolomite
			17-21	Loxton-Parilla Sands
			21-40 TD	Murray Gp limestone
6727-1470	329003	6090292	0-17	Quaternary dolomite
			17-59	Murray Gp limestone
			59-115	Renmark Group
			115-117TD	Cambrian basement
6727-1482	331491	6089264	0-18	Quaternary dolomite
			18-23	Loxton-Parilla Sands
			23-36 TD	Murray Gp limestone
6727-1501	327864	6085276	0-13	St Kilda Fmn
			13-21	Loxton-Parilla Sands
			21-26 TD	Murray Gp limestone
6727-1505	329296	6085757	0-14	St Kilda Fmn
(DM15)			14-70	Murray Gp limestone
			70-113	Renmark Group
			113-123TD	Cambrian basement
6727-1527	323227	6084473	0-12	Quaternary
(DM1)			12-29	Loxton-Parilla Sands
			29-81	Murray Gp limestone
			81-131	Renmark Gp
			131-131TD	Permian
6727-1561	325037	6083629	0-18	Quaternary
			18-22	Loxton-Parilla Sands
			22-30TD	Murray Gp limestone
6727-1617	318490	6083792	0-29	Quaternary
			29-39TD	Murray Gp limestone
6727-1624	318931	6086392	0-31	Quaternary
			31-53TD	Murray Gp limestone
6727-1704	322488	6089759	0-46	Quaternary
			46-89	Murray Gp limestone
			89-116	Renmark Group
			116-117TD	Cambrian basement
6727-1798	320311	6095799	0-37	Quaternary
			37-57TD	Murray Gp limestone

6727-1860	322367	6092736	0-37	Quaternary
			37-64	Murray Gp limestone
			64-66TD	Renmark Group
6727-1861	322466	6092763	0-34	Quaternary
DM5)			34-39	Loxton-Parilla Sands
			39-66TD	Murray Gp limestone
6727-1867	321816	6092544	0-35	Quaternary
(DM4)			35-75	Murray Gp limestone
			75-119	Buccleuch beds
			119-122TD	Cambrian basement
6727-1888	318465	6095017	0-29	Quaternary
(DM26)			29-33	Loxton-Parilla Sands
			33-43	Murray Gp limestone
			43-46	Ettrick Fmn
			46-68	Buccleuch beds
			68-70TD	Cambrian basement
6727-1964	321349	6092227	0-32	Quaternary
			32-46TD	Murray Gp limestone
6727-2023	319307	6089112	0-41	Quaternary
			41-46TD	Murray Gp limestone

APPENDIX 12

SUMMARY OF PROJECT DRILLING

Drilling was carried out at eleven sites in the project area to provide stratigraphic control and wireline conductivity logs. Several holes were finished as piezometers, the remainder were backfilled, with cementing of aquifers if required.

Sedimentary materials are described in terms of their grainsize components – pebbles (4-64 mm), granules (2 - 4 mm), sand (62.5 microns - 2 mm), silt (4 - 62.5 microns), and clay (<4 microns), not soil texture. Most samples of non-carbonate sediment with grains <2 mm have been analysed for grainsize using the Malvern Instruments Mastersizer laser grainsize facility operated by Marine Division at Geoscience Australia (Appendix 14). Visual estimates based on hand lens/binocular microscope observations of grainsize/lithology for samples not included in Appendix 14 are presented in Appendix 13.

Summaries of the drill holes including wireline logs, lithology column and EC1:5 and moisture are presented by Jones *et al.* (2003).

AB01

Location	319444 6104653, North Bremer Road, Hartley area, on roadside verge, west side of road. Elevation 55 m (from magspec DEM). About half way between AEM flight lines 20110 and 20120.
Purpose	To test the thickness and nature of alluvial sediment in the upper Bremer River alluvial plain, determine the possible presence of underlying Tertiary limestone, provide a conductivity profile, and finish the drill hole as a piezometer for continued testing of groundwater upstream of main Angas-Bremer alluvial plain.
Landform	Alluvial plain of Bremer River with scattered irregular aeolian source-bordering dunes.
Drill Method	Aircore. Initial attempts at wireline logging unsuccessful due to hole caving in. Wireline logs taken after the piezometer was completed, and thus do not go far into basement.

Depth	**Cuttings/interpretations of lithology**
0-7	Dry to slightly damp very poorly sorted very fine to medium silty sand to sandy silt. Slightly micaceous.
7-10	Dry to slightly damp poorly sorted very fine to coarse silty sand. Slightly micaceous.
10-15	Damp poorly sorted very fine to medium silty sand with up to 50% granules and small pebbles (subrounded quartz and rock fragments to 50 mm). Slightly micaceous.
15-18	Very damp to wet poorly sorted very fine to coarse silty sand with ~30% granules and small pebbles (subrounded quartz and rock fragments to 50 mm). Slightly micaceous.
18-21.3	Poor cuttings return 18-20 m, slurry of silt and fine sand in water. 20-21 m good sample of fine silty sand. 21-22 m mixture of fine very silty sand and powdered grey basement shale. Base of sediment taken as 21.3 m from interpretation of the gamma log.
21.3-30	Powdered grey basement micaceous siltstone.

Tertiary limestone crops out and subcrops continuously along the eastern margin of the alluvial landform tract along this part of the Bremer River and in scattered outliers to the west (Johns, 1960; Lindsay & Williams, 1977; author's observations). The alluvium appears to be in contact with the Tertiary limestone to the east of the river (eg Figure 35 section B-J). Thus there is potential for recharge to the limestone aquifer by lateral groundwater flow from the alluvium in this area, especially during flood times when there will be vertical recharge in the alluvium from flood water, creating a local groundwater mound and gradient away from the river and towards the limestone aquifer. However, even the gravelly beds in the alluvium in this hole are quite silty, probably reducing the hydraulic conductivity of the sediment and limiting recharge. The surface of the alluvial plain is characterised by an undulating surface with several metres relief, due to levees, terracing and accumulation of source-bordering aeolian dunes. Thus prior to settlement there may have been the potential for large amounts of standing water to accumulate in local low areas on the alluvial plain at times of high flood discharge, adding to local recharge away from the river channel.

The thickness of alluvium implies former erosion by the Bremer River to form an incised palaeovalley in this area at least 23 m below current ground level (i.e. base of palaeovalley at 32 m asl or below). The alluvial plain at the drill hole location narrows downstream, and the river runs through an incised bedrock floored valley (river bed at ~45 m estimated from the radar DEM) from about 2.5 km downstream of the hole. Thus at the hole location the river has eroded to what is now a lower level than bedrock in the floor of the valley downstream by ~13 m. This could possibly be attributed to deep scouring, but tectonic influences (warping) to form variations in the elevations of the sediment/bedrock contact cannot be discounted.

AB02

Location	307139 6088238. In paddock near the southeast corner of the farmhouse yard on the WAITE property near Sandergrove Creek. At station 2345 of Angas Bremer Plains ground EM line 3. About 10 m from AEM flight line 20280. Elevation 40 m from magspec DEM.
Purpose	To test the thickness and nature of sediment in an area with known (from drillers' logs) relatively thick sediment on the downthrown side of the Sandergrove Fault, and to provide wireline logs for calibration of the EM surveys in an area of high conductivity.
Landform	Low relief alluvial plain (coalesced low angle fans of ephemeral streams originating in upland areas to the west and flowing to Sandergrove Creek) inclined to the southeast.
Drill Method	Aircore. Initial attempts at wireline logging were unsuccessful due to the hole caving in. Logs were taken after PVC casing was pushed into the hole and cleared with compressed air.

Depth	**Cuttings/interpretation of lithology**
0-19	Brown yellow and grey dry to damp sand/silt/clay. Calcareous 1-2 m. Locally cemented (drill pipe chatter, slow drilling) 12-19 m
19-25	Dry to damp poorly sorted very fine to coarse silty sand.
25-45	Yellow with minor green calcarenite with minor fine quartz grains. Some larger fragments have shelly fossil moulds.
45-46	Green calcareous clay with brown ferruginous? rounded sand sized grains and quartz grains
46-47	Yellow brown and green calcarenite and calcareous clay
47-54	Powdered grey basement micaceous siltstone.

This hole shows that there is a considerable thickness of sediment west of Sandergrove Creek, and that it is at least in part of Tertiary age. The calcarenite and clay sequence is most probably of Oligocene-Miocene age based on lithological correlation with dated sections elsewhere in the region (eg Lindsay & Williams, 1977; Lindsay & Kim, 1971; Lablack, 1991). The sandy sequence between 19-25 m overlying the limestone may be equivalent to partly cemented and mottled silty sandstone (with local pebbles and granules) cropping out in an erosion gully ~ 2 km to the northwest of the drill site (between 306212 6090689 and 305951 6090860). This may be of early Quaternary age, part of the Currency Creek Formation of Maud (1972). The boundary between this and the Quaternary alluvial plain sediment present at the surface may be at 19 m, but this is uncertain as some of the sediment between 12 and 19 m is cemented, suggesting an older age. None of the shallow material resembles the red/brown locally calcareous silty alluvium that overlies the mottled sandstone in the gully mentioned above (up to ~6 m exposed in gully walls), but the difference in colour may be due to local water saturation conditions.

AB03

Location	308056 6087862. Immediately northeast of intersection of Dry Plains and Tucker Roads, on the upper part of the Sandergrove Fault scarp. About 200 m northeast and along structural strike from ground EM station 3325 on Angas Bremer ground EM line 3, and about 40 m from AEM line 20300. Elevation 43 m from magspec DEM.
Purpose	To test the thickness and nature of sediment over basement on the upthrown side of Sandergrove Fault and to provide wireline logs for calibration of the EM surveys in an area with a shallow resistor.
Landform	Erosional rise, fault scarp.
Drill Method	Aircore to 11 m, then jackhammer RAB.

Depth	**Cuttings/interpretation of lithology**
0-10	Damp red brown and grey sand/silt/clay, minor rounded pebbles to 30 mm 9-10 m.
10-19	Hard grey micaceous fine sandstone/greywacke as chips and grains.

This hole confirms presence of shallow basement as predicted by shallow resistive materials in airborne and ground EM surveys. It is considered highly unlikely that the sedimentary sequence over basement has been locally derived, as the location is within 200 metres distance and 2 metres elevation of the drainage divide between Sandergrove Creek and the Angas River. The pebbles in the 9-10 m interval indicate a basal gravel in the sedimentary sequence. Hence it is interpreted that at least the lower part of the sequence predates faulting, being deposited by a sedimentary system that was unrelated to modern landscape and terminated by faulting and uplift. The upper part of the sequence could possibly have been locally derived after faulting, with transport by sheet flow from upslope or by aeolian accession from the west.

AB04

Location	308923 6087057. In paddock of "Chaslyn Vale" property, at station 4485 of Angas Bremer ground EM line 3 and about 10 m from airborne EM line 20330. Elevation 37 m from magspec DEM.
Purpose	To test thickness and nature of sediment on the upthrown side of the Sandergrove Fault and provide conductivity log for calibration of EM data.
Landform	Gently inclined aeolian depositional plain with local low dunes.
Drill Method	Aircore to 10 m, then RAB, using water injection 24-30 m to assist recovery of cuttings due to lost air circulation.

Depth	**Cuttings/interpretation of lithology**
0-17	Damp sand/silt/clay, pale yellow/grey and red/brown down to 10 m, and yellow/grey below. Generally becomes less sandy with depth.
17-29	Calcarenite with variable quartz grain content.
29-34	Powder and small chips of hard grey micaceous very fine sandstone.

The hole showed that the basic sequence of clastic sediment over Tertiary limestone over basement is present southeast of and close to the Sandergrove Fault, but the limestone is thinner than where intersected in logged bores 3 km to the east (eg hole DM16, 6627-864, which intersected Tertiary sediment/limestone between 23 and 69.5 m; Appendix 8). Note that AB04 was dry, indicating that the base of the limestone at ~ +8m is above water table. Further downslope, drill hole 6672-864 has surveyed elevation of 29.5 m (Appendix 1), and swl is currently ~27 m depth (from Dept Water Land and Biodiversity Conservation website, Angas Bremer observation bore network), within the limestone aquifer. The top of the limestone aquifer in this hole is at 23 m depth, therefore the aquifer is not sub artesian, with water table at ~ +2.5m elevation within the Tertiary limestone unit.

AB05A, 5B and 5C

Location	320207 6094087 (AB05A, other holes ~2.5 and 5 m south). East bank of Bremer River, 2 km northwest of Langhorne Creek. Access from Woodchester-Langhorne Creek road, via farm track across river. Elevation 22 m from magspec DEM.
Purpose	To test thickness and nature of sediment on the alluvial plain in an area of low AEM conductivity, provide conductivity log for calibration of EM data, and finish as a piezometers.
Landform	Alluvial plain, with several metres local relief due to terracing, local flood scour and accumulation of aeolian deposits.
Drill method	AB05A aircore to 36 m, circulation lost at 36 m. Rotary drilled with mud 36-39 m. 150 mm casing then installed to 39 m. 39-84 m drilled by RAB, with hole making water at about 5 litres/second (lifted by air bubbles). Abandoned at 84 m due to sand caving in. AB05B and C drilled by RAB.

Depth	**Cuttings/interpretation of lithology**
0-35	Poorly sorted silty sand and sandy silt, generally becoming siltier with depth. Sand mostly very fine to medium. The driller thought that the interval 32-33 m might be sandy and caving in, although cuttings returns were silty.
35-36	Poorly sorted very fine to coarse sand with 5% small pebbles and granules. Generally poor cuttings return due to loss of air into the formation. May be Pliocene Loxton-Parilla Sands equivalent, or a basal sandy part of the Quaternary sequence.
36-72	Yellow calcarenite, with variable quartz grain content, locally >50%. Most probably Miocene age.
72-80	Poorly sorted angular to well rounded quartz sand, with subangular to subrounded granules and pebbles to 30 mm, minor dark grey clay.
80-84	Fine to medium sand with shell fragments and glauconite.

The wireline logs and cuttings show that there is variability in the grainsize of the Quaternary sediment down to 35 m. Bulk cuttings samples contain appreciable silt, but individual beds within the sediment may be better sorted and have higher hydraulic conductivity than would be suggested by the bulk grainsize.

AB06A, AB06B

Location	AB06A 318082 6083891, AB06B about 3 m to the south. East bank of Angas River, about 5 km northeast of Milang. Access through vineyards via homestead off a major north-south road. Elevation 4 m from magspec DEM.
Purpose	To test thickness and nature of sediment on the alluvial plain in an area of low AEM conductivity, provide conductivity log for calibration of EM data, and finish as piezometers in the Tertiary limestone aquifer (AB06A) and Quaternary sequence (AB06B) in an area adjacent to the Angas River.
Landform	Alluvial plain, with local relief of about 1 m. The area was being levelled at the time to drilling to reduce local relief prior to planting new vines.
Drill method	AB06A drilled RAB to 18 m, rotary mud 18-54 m. The hole was making water from about 10 m during RAB drilling, but losing mud at deeper depths. Drilling was stopped at 54 m due to financial constraints. AB06 B was drilled to 18 m by RAB.

Depth	**Cuttings/interpretation of lithology**
0-25	Poorly sorted sandy silt. 0-2 m black organic-rich mud. Some carbonate in the 1-2 m sample.
25-54	Calcarenite with minor quartz grain content

The depth to the limestone aquifer was a little less than predicted from records of surrounding bores, which intersected around 30 m of Quaternary sediment over limestone. The mudpit dug for the hole exposed black organic mud with several thin beds of fine sand. These more sandy beds are not apparent from the bulked cuttings samples, and may be present throughout the Quaternary sequence down to 25 m. Exposures of the black organic mud in the banks of the adjacent Angas River contained shell fossils. It is probable that this is a swamp or possible lake deposit. The present channel of the Angas River has been excavated by local landowners to allow rapid transit of floodwater through the area, and the swamp may have existed up to the time of excavation.

AB07

Location 315133 6093924. Access via homestead off Eckerts Road. At station 160 of Angas Bremer Plains ground EM traverse 1, 30 m from AEM flight line 30280. Elevation 33 m from magspec DEM.

Purpose To test thickness and nature of sediment on the flanks of an erosional landform known to have basement at relatively shallow depth, but mostly sheathed in sandy material, to test a relatively shallow conductor on both ground and airborne EM surveys, and provide conductivity log for calibration of EM data.

Landform Gently sloping lower erosional flank of low hills.

Drill method RAB to TD 30 m.

Depth	**Cuttings/interpretation of lithology**
0-8	Poorly sorted sandy silt to silty sand. Sand very fine to medium grained. Minor carbonate 0-1 m.
8-9	Poorly sorted very fine to coarse silty sand.
9-11	Poorly sorted medium to very coarse sand with granules and small pebbles to 4 cm of subrounded to subangular quartz and rock fragments. Some small maghemite grains.
11-30	Powdered grey micaceous siltstone and very fine sandstone/greywacke (high conductivity on EM 39 probe)

The drill site at 33 m elevation is well above the depositional surface of the Angas Bremer alluvial plain (~26 m in this area, estimated from Magspec DEM), so the sediment is not related to the Angas-Bremer River alluvial system. It is probable that it is related to marine to estuarine Tertiary clastic sediment exposed beneath Tertiary limestone in quarries 5 km to the northwest near Strathalbyn – either as in situ Tertiary sediment, or Quaternary, reworked downslope by wind/water from Tertiary deposits. The wireline logs show that the conductivity anomaly in the AEM data is in the top part of the basement, not the sediment. The basal gravelly sand contained a small amount of water, and the hole had some water in it when logged, immediately after drilling.

AB08

Location	316123 6094138 On road verge, western side of Eckerts Road, south of T junction with an east-trending road. Location is beneath AEM flight line 30290, and has similar AEM response to station 1142 on the Angas Bremer ground EM line 1 (600 m distant). Elevation 26 m from magspec DEM.
Purpose	To test thickness and nature of sediment near the margin of the Angas Bremer alluvial plain, to test a resistive area on both ground and airborne EM surveys, and provide conductivity log for calibration of EM data.
Landform	Low relief alluvial plain, close to the boundary with low hills to the east.
Drill method	Drilled with RAB to TD 30 m. Hole was blocked at 15 m when wireline logging first attempted. Casing was then pushed into the hole and cleared with compressed air to allow logging. This was then withdrawn and the hole backfilled.

Depth	**Cuttings/interpretation of lithology**
0-15	Poorly sorted micaceous sandy silt. Sand very fine to medium.
15-17	Medium to very coarse sand with granules and pebbles (subangular to rounded rock fragments and quartz) to 4 cm. Some sand to granule sized rounded maghemite grains.
17-30	Powdered micaceous siltstone and sandstone/greywacke. Yellow cuttings to 20, then yellow grey. Cavings of sand and gravel 17-19m.

The drill site is on the Angas Bremer alluvial plain, so at least the upper part of the sediment should be Quaternary, deposited by the Angas-Bremer River system. It is possible at this location that this material overlies older sandy sediment (related to Tertiary depositional systems, and possibly of marine origin) continuous with that encountered in AB07. The sediment down to 15 m is silt dominated and micaceous, so it is considered that the interval 0-15 m in AB08 is Quaternary. However, it is not certain whether the basal 2 m of coarser sediment is part of the Quaternary sequence or is older.

AB09

Location	316897 6083816. In paddock, access from track to house from Milang-Strathalbyn road. At station 1600 of Angas Bremer ground EM line 2, about 50 m from AEM flight line 20510. Elevation 3 m from magspec DEM.
Purpose	To test thickness and nature of Quaternary clastic sediment in this part of the Angas Bremer alluvial plain, to test an area of shallow conductivity on both ground and airborne EM surveys, and provide a conductivity log for calibration of EM data.
Landform	Local low point on low relief alluvial plain.
Drill method	RAB to TD 30 m. After logging, the Tertiary limestone aquifer was cemented off from the overlying Quaternary sediment. The hole made water during drilling from 12 m depth.

Depth	**Cuttings/interpretation of lithology**
0-17	Poorly sorted sand/silt/clay.
17-19	Clayey and silty very fine to medium sand.
19-30	Calcarenite with 10-60% quartz grains. Poor cuttings return due to large amount of water coming out of the hole with air lift.

The hole is at a local low point in the landscape, where water accumulates during floods (up to knee high in recent times according to the landowner). The hydrostatic head of the limestone aquifer is very shallow, as observed in a production bore near AB09, which used a suction uplift rather than submersible pump. Hence the local topographic low is probably a zone in which water is discharging by evapotranspiration. This would explain the high local shallow conductivity in both AEM and ground EM data.

AB10

Location	315510 6083838. In paddock, access from gate on east-west road to the north of the site. At station 3000 of Angas Bremer ground EM line 2, about 10 m from AEM flight line 20490. Elevation 6 m from magspec DEM.
Purpose	To test thickness and nature of Quaternary clastic sediment, to test an area of shallow conductivity, and provide a conductivity log for calibration of EM data.
Landform	Slightly undulating sand plain.
Drill method	RAB to TD 18 m.

Depth	**Cuttings/interpretation of lithology**
0-8	Yellow and red/brown to grey sand/silt/clay. Minor calcrete 0-2 m.
8-12	Red brown and grey moderately fine to medium well sorted silty sand.
12-16	Calcarenite with some quartz grains.
16-18	Silty very fine to medium sand.

The Tertiary limestone was several metres shallower than expected (the nearest holes with geological interpretation intersected limestone at 17-23 m). The sandy sediment at 8-12 m could possibly be Pliocene Loxton-Parilla Sands.

AB11

Location	317442 6092890. Located on the verge of a north-south road. At station 2742 of Angas Bremer ground EM line 1, about 20 m from AEM flight line 20330. Elevation 22 m from magspec DEM.
Purpose	To test thickness and nature of Quaternary clastic sediment, and provide a conductivity log for calibration of EM data.
Landform	Alluvial plain.
Drill method	RAB to 17 m. Air circulation lost at 17 m, and hole abandoned due to financial constraints.

Depth	**Cuttings/interpretation of lithology**
0-1	Red/brown micaceous silty very fine to medium sand.
1-5	Red/brown micaceous sand/silt/clay mixture.
5-10	Red/brown to yellow/brown micaceous very fine to fine sandy silt.
10-17	Yellow/brown micaceous silty sand. Sand mostly very fine to medium, but 16-17 m very fine to coarse.

The hole probably bottomed in a bed of coarse sand (with high permeability, hence loss of air pressure while drilling) within Quaternary alluvial sediment. The water table was not reached. The nearest drill hole with available geological data (6627-7180, about 600 m to the south) encountered 36 m of Quaternary sediment.

APPENDIX 13

LITHOLOGY IN PROJECT DRILLHOLES

Visually estimated lithology data from cuttings of project drill holes are presented. Detailed laser grainsize data are given in Appendix 14, which complements this appendix. Most samples that are described here have not been subjected to laboratory grainsize analysis for one of several possible reasons:

- they contain cemented carbonate, thus cuttings include broken fragments which may not reflect the original grain size distribution
- they contain grains and clasts > 2mm, which cannot be determined by the laser grainsize facility
- poor cuttings return, thus the cuttings may not represent the interval drilled and were not considered worthwhile for analysis
- organic matter in cuttings

Three samples in this table also have data in Appendix 14. AB03 10 m sand silt and clay figures from Appendix 14 have been recalculated to 98% for this table as this sample contained estimated 2% gravel which was not included in the laser grainsize sample. Samples from AB04 1 and 2 m contained estimated 5% powdery calcrete that was acid dissolved prior to grainsize analysis. The sand silt and clay figures in Appendix 14 have been recalculated to 95% in the data presented here for these two samples.

Sample	**Clay**	**Silt**	**Sand (non carbonate)**	**Gravel (non carbonate)**	**Carbonate**	***Comments***
AB01 1m						*No sample*
AB01 11m		5	45	50		
AB01 12m		5	45	50		
AB01 13m		5	45	50		
AB01 14m		5	45	50		
AB01 15m		5	45	50		
AB01 16m		8	67	25		
AB01 17m		8	65	27		
AB01 18m		8	62	30		
AB01 21.3-30 m						*Basement – grey micaceous siltstone*
AB02 26m					100	
AB02 27m					100	
AB02 28m			5		95	
AB02 29m			5		95	
AB02 30m			5		95	
AB02 31m			5		95	
AB02 32m			5		95	
AB02 33m			5		95	
AB02 34m			5		95	
AB02 35m					100	
AB02 36m			10		90	
AB02 37m			10		90	
AB02 38m			5		95	
AB02 39m			5		95	
AB02 40m			5		95	
AB02 41m			5		95	
AB02 42m			5		95	
AB02 43m			5		95	
AB02 44m			5		95	
AB02 45m			10		90	
AB02 46m	60		5		35	
AB02 47m	10		10	5	75	
AB02 47-54 m						*basement - grey micaceous siltstone*
AB03 10m	12.10	38.75	47.15	2		*gravel estimated, size data recalculated to 98%*
AB03 10-19 m						*basement - hard grey micaceous fine sandstone/greywacke*
AB04 1m	21.85	33.11	40.05		5	*calcrete estimated, size data recalculated to 95%*
AB04 2m	20.65	42.35	32.01		5	*calcrete estimated, size data recalculated to 95%*
AB04 17m	5	45	50			
AB04 18m			30		70	
AB04 19m			50		50	
AB04 20m			80		20	
AB04 21m			5		95	
AB04 22m			5		95	
AB04 23m			5		95	
AB04 24m			5		95	
AB04 25m			20		80	
AB04 26m			20		80	
AB04 27m			50		50	
AB04 28m			50		50	
AB04 29m			50		50	

Sample	**Clay**	**Silt**	**Sand (non carbonate)**	**Gravel (non carbonate)**	**Carbonate**	***Comments***
AB04 29-34m						*Basement – hard grey micaceous very fine sandstone*
AB05A 36m		5	90	5		
AB05A 37m			10		90	
AB05A 38m			15		85	
AB05A 39m			5		95	
AB05A 40m			20		80	
AB05A 41m			60		40	
AB05A 42m			50		50	
AB05A 43m			50		50	
AB05A 44m			40		60	
AB05A 45m			30		70	
AB05A 46m			20		80	
AB05A 47m			20		80	
AB05A 48m			5		95	
AB05A 49m			2		98	
AB05A 50m			2		98	
AB05A 51m	3		2		95	
AB05A 52m			5		95	
AB05A 53m			25		75	
AB05A 54m			5		95	
AB05A 55m			25		75	
AB05A 56m			10		90	
AB05A 57m			25		75	
AB05A 58m			15		85	
AB05A 59m			2		98	
AB05A 60m			2		98	
AB05A 61m			50		50	
AB05A 62m			30		70	
AB05A 63m			5		95	
AB05A 64m			20		80	
AB05A 65m			25		75	
AB05A 66m			80		20	
AB05A 67m			60		40	
AB05A 68m			50		50	
AB05A 69m			50		50	
AB05A 70m			50		50	
AB05A 71m			50		50	
AB05A 72m			30		70	
AB05A 73m			85	15		
AB05A 74m			85	15		
AB05A 75m	2		83	15		
AB05A 76m	2		83	15		
AB05A 77m	2		83	15		
AB05A 78m	2		83	15		
AB05A 79m	5		80	15		
AB05A 80m	5		90	5		
AB05A 81m		5	95			
AB05A 82m		5	95			
AB05A 83m		5	95			
AB05A 84m		5	95			
AB06B 1m	2	20	78			
AB06B 2m	20	60	20			*High organic content, estimates for mineral component only*
AB06A 19m	5	40	55			*Poor cuttings return*

Sample	Clay	Silt	Sand (non carbonate)	Gravel (non carbonate)	Carbonate	*Comments*
AB06A 20m	5	40	55			*Poor cuttings return*
AB06A 21m	5	60	35			*Poor cuttings return*
AB06A 22m	5	60	35			*Poor cuttings return*
AB06A 23m	5	60	35			*Poor cuttings return*
AB06A 24m	5	60	35			*Poor cuttings return*
AB06A 25m	5	60	35			*Poor cuttings return*
AB06A 26m			5		95	
AB06A 27m			5		95	
AB06A 28m			5		95	
AB06A 29m			5		95	
AB06A 30m			5		95	
AB06A 31m			5		95	
AB06A 32m			2		98	
AB06A 33m			2		98	
AB06A 34m					100	
AB06A 35m					100	
AB06A 36m					100	
AB06A 37m			5		95	
AB06A 38m			5		95	
AB06A 39m			10		90	
AB06A 40m			10		90	
AB06A 41m			10		90	
AB06A 42m			10		90	
AB06A 43m			2		98	
AB06A 44m			5		98	
AB06A 45m					100	
AB06A 46m			2		98	
AB06A 47m			2		98	
AB06A 48m					100	
AB06A 49m			5		95	
AB06A 50m					100	
AB06A 51m					100	
AB06A 52m			5		95	
AB06A 53m					100	
AB06A 54m					100	
AB07 10m		5	90	5		
AB07 11m		5	80	15		
AB07 11-30 m						*basement - grey micaceous siltstone and very fine sandstone/greywacke*
AB08 16m		2	73	25		
AB08 17m			25	75		
AB08 17-30 m						*basement - yellow-grey micaceous siltstone and sandstone/greywacke*
AB09 20m			80		20	
AB09 21m			20		80	
AB09 22m			10		90	
AB09 23m			10		90	
AB09 24m						
AB09 25m			60		40	
AB09 26m			60		40	
AB09 27m			60		40	
AB09 28m			30		70	
AB09 29m			20		80	
AB09 30m			40		60	

Sample	**Clay**	**Silt**	**Sand (non carbonate)**	**Gravel (non carbonate)**	**Carbonate**	***Comments***
AB10 13m			20		80	
AB10 14m			20		80	
AB10 15m			10		90	
AB10 16m			20		80	
AB10 17m		40	60			
AB10 18m		40	60			

APPENDIX 14

LASER GRAINSIZE OF SAMPLES FROM PROJECT DRILLHOLES

Depth and grainsize data for samples from project drill holes are presented. Depths of samples listed are the base of 1 metre intervals over which cuttings were collected, except for AB03 22 m which is actually for the interval 21.0-21.3 m. Grainsize was determined using the laser diffraction (Mastersizer) grainsize facility at Geoscience Australia. Sizes are given as both microns and Phi scale units. Grainsizes are equivalent sphere sizes, and percent composition is by volume, rather than by mass (as is presented for sieve/settling tube analysis). Controlled grainsize studies (eg Campbell 2003) show that fine fractions may be underestimated by the laser method. It is not known if this is the case for the samples analysed here.

The sample from AB03 10 m contained visually estimated 2% gravel which was not included in the sample analysed – the sand silt and clay figures presented in this appendix have been recalculated to 98% in the whole of sample data presented in Appendix 13. The samples from AB04 1 and 2 m contained an estimated 5% powdery regolith carbonate. The samples were acid treated to remove this prior to grainsize analysis. The sand silt and clay figures presented in this appendix have been recalculated to 95% in the whole of sample data presented in Appendix 13. The samples from AB10 1 and 2 m were also treated with HCl before grainsize analysis was carried out. The amount of carbonate in these samples has not been estimated, so a recalculation has not been attempted.

Drill hole and depth	AB01 2m	AB01 3m	AB01 4m	AB01 5m	AB01 6m	AB01 7m	AB01 8m	AB01 9m	AB01 10m	AB01 19m	AB01 20m
10 percentile (μ)	5.76	3.87	4.64	3.28	4.86	8.69	16.66	25.13	19.70	3.34	2.14
50 percentile (μ)	93.50	59.01	51.69	32.88	37.49	109.4	156.6	184.6	231.3	67.20	58.03
90 percentile (μ)	295.1	181.5	154.0	127.3	186.3	364.9	306.3	341.3	502.9	326.2	284.6
Mode (μ)	131.7	95.09	85.87	70.87	48.39	237.0	188.2	208.9	256.0	194.7	161.5
Secondary modes (μ)							28.01	27.06	27.70	0.77	0.67
											743.7
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	0.28	0.42	0.34	0.39	0.38	0.16	0.07	0.00	0.09	0.88	1.87
0.98 μ (10 θ)	1.77	2.52	2.12	2.64	2.21	1.27	0.75	0.56	0.78	3.51	5.88
2 μ (9 θ)	4.18	5.67	4.72	6.18	4.64	2.96	1.97	1.48	1.82	6.63	9.61
3.9 μ (8 θ)	7.64	10.06	8.71	11.58	8.36	5.50	3.86	2.89	3.39	11.22	14.22
7.8 μ (7 θ)	12.05	15.84	14.76	19.59	14.65	9.26	6.38	4.87	5.63	17.92	20.53
15.6 μ (6 θ)	17.91	23.87	24.14	32.13	26.19	15.06	9.61	7.40	8.68	27.10	29.43
31 μ (5 θ)	25.15	34.30	36.64	48.46	44.11	23.73	14.42	11.31	12.99	37.38	39.85
37 μ	27.49	37.73	40.64	53.16	49.58	26.61	15.72	12.31	14.11	40.09	42.60
44 μ	30.19	41.66	45.15	58.03	55.14	29.72	16.89	13.09	15.02	42.81	45.35
53 μ	33.75	46.68	50.81	63.61	61.19	33.36	18.12	13.67	15.70	45.85	48.42
62.5 μ (4 θ)	37.61	51.90	56.58	68.83	66.48	36.81	19.42	14.15	16.06	48.69	51.34
74 μ	42.31	57.94	63.10	74.31	71.63	40.54	21.38	14.99	16.39	51.81	54.62
88 μ	47.89	64.66	70.16	79.86	76.47	44.56	24.64	16.87	17.10	55.31	58.37
105 μ	54.22	71.70	77.27	85.11	80.76	48.92	29.87	20.64	18.78	59.24	62.68
125 μ (3 θ)	60.86	78.39	83.68	89.57	84.28	53.59	37.28	26.86	22.05	63.53	67.39
149 μ	67.65	84.43	89.11	93.12	87.13	58.78	46.93	35.87	27.45	68.25	72.48
177 μ	74.10	89.37	93.20	95.63	89.40	64.44	57.89	47.03	34.93	73.19	77.59
210 μ	80.08	93.17	96.04	97.28	91.30	70.56	69.20	59.40	44.20	78.22	82.51
250 μ (2 θ)	85.54	95.96	97.88	98.31	93.04	77.07	79.92	71.96	54.79	83.23	87.07
300 μ	90.40	97.86	98.98	98.94	94.74	83.70	89.12	83.49	66.01	88.02	91.06
350 μ	93.75	98.84	99.48	99.28	96.08	88.76	94.77	91.08	74.76	91.53	93.74
420 μ	96.78	99.52	99.84	99.60	97.49	93.67	98.84	97.06	83.49	94.90	96.09
500 μ (1 θ)	98.73	99.82	99.95	99.85	98.58	97.06	99.99	99.92	89.82	97.30	97.62
590 μ	99.78	99.92	100.0	99.99	99.34	99.10	100.0	100.0	94.04	98.86	98.52
710 μ	100.0	99.98	100.0	100.0	99.84	100.0	100.0	100.0	97.06	99.75	99.00
840 μ	100.0	100.0	100.0	100.0	99.98	100.0	100.0	100.0	98.62	99.99	99.39
1000 μ (0 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.37	100.0	99.71
1190 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.74	100.0	99.90
1410 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.93	100.0	99.99
1680 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2000 μ (-1 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% grainsize											
clay (<4μ)	7.64	10.06	8.71	11.58	8.36	5.50	3.86	2.89	3.39	11.22	14.22
silt (4 - 63μ)	29.97	41.84	47.87	57.25	58.11	31.31	15.56	11.26	12.67	37.47	37.12
sand (63μ - 2 mm)	62.39	48.10	43.42	31.17	33.52	63.19	80.58	85.85	83.94	51.31	48.66

Drill hole and depth	AB01 21m	AB01 21.3m	AB02 1m	AB02 2m	AB02 3m	AB02 4m	AB02 5m	AB02 6m	AB02 7m	AB02 8m	AB02 9m
10 percentile (μ)	1.75	0.66	2.11	1.40	0.76	1.36	1.60	1.52	1.93	2.68	2.98
50 percentile (μ)	92.11	13.14	15.34	13.01	5.66	13.28	37.39	27.00	19.70	61.76	25.60
90 percentile (μ)	244.1	520.1	162.7	75.58	159.2	233.9	213.0	220.4	186.9	270.4	171.8
Mode (μ)	156.1	569.0	12.28	15.00	3.14	10.74	96.57	110.7	14.64	142.9	20.60
Secondary modes (μ)	21.11	10.66	102.3	0.84	96.32	68.79	16.44	13.17	90.20	15.65	0.72
	2.97	4.26	0.84	352.0				0.78	0.79	0.76	
	0.65	0.60									
		110.4									
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	2.30	5.80	1.11	1.46	3.22	1.34	1.73	2.03	1.53	1.34	1.13
0.98 μ (10 θ)	6.59	14.95	4.98	6.97	14.40	6.77	6.30	6.81	5.54	4.42	4.09
2 μ (9 θ)	10.93	22.37	9.58	13.33	27.67	14.66	11.94	12.33	10.29	8.04	7.35
3.9 μ (8 θ)	16.10	31.66	16.62	21.69	42.20	25.41	18.74	19.43	17.03	12.98	12.30
7.8 μ (7 θ)	21.05	42.02	30.27	34.98	56.20	38.66	26.83	28.89	27.67	19.94	21.34
15.6 μ (6 θ)	26.64	52.54	50.49	56.03	67.94	53.30	36.60	41.00	44.13	29.67	36.80
31 μ (5 θ)	33.04	60.72	66.34	76.15	75.95	64.78	46.89	52.03	59.71	39.58	55.00
37 μ	34.67	62.30	69.11	79.91	77.49	67.22	49.82	54.59	62.85	41.97	59.50
44 μ	36.35	63.76	71.54	83.00	78.92	69.59	52.97	57.17	65.73	44.39	63.77
53 μ	38.47	65.34	74.02	85.80	80.44	72.17	56.75	60.19	68.77	47.27	68.23
62.5 μ (4 θ)	40.87	66.83	76.23	87.90	81.82	74.52	60.48	63.15	71.54	50.23	72.05
74 μ	44.14	68.50	78.58	89.78	83.28	76.95	64.62	66.50	74.49	53.76	75.79
88 μ	48.61	70.39	81.10	91.47	84.81	79.42	69.11	70.25	77.64	57.96	79.41
105 μ	54.48	72.46	83.72	92.96	86.39	81.81	73.80	74.29	80.86	62.81	82.76
125 μ (3 θ)	61.46	74.54	86.30	94.20	87.93	83.99	78.32	78.34	83.91	68.00	85.68
149 μ	69.32	76.53	88.81	95.22	89.44	85.95	82.61	82.29	86.76	73.42	88.22
177 μ	77.21	78.31	91.10	96.04	90.88	87.64	86.42	85.91	89.26	78.67	90.35
210 μ	84.51	79.87	93.17	96.71	92.27	89.14	89.74	89.15	91.48	83.61	92.20
250 μ (2 θ)	90.76	81.33	95.03	97.32	93.68	90.50	92.66	92.05	93.50	88.15	93.92
300 μ	95.58	82.91	96.69	97.95	95.13	91.81	95.19	94.64	95.40	92.22	95.59
350 μ	98.21	84.46	97.85	98.50	96.33	92.84	96.94	96.47	96.83	95.03	96.90
420 μ	99.71	86.73	98.92	99.15	97.65	93.98	98.54	98.20	98.26	97.55	98.27
500 μ (1 θ)	99.99	89.36	99.60	99.67	98.72	95.01	99.54	99.35	99.28	99.13	99.27
590 μ	100.0	92.10	99.96	99.96	99.46	95.92	99.97	99.96	99.85	99.90	99.86
710 μ	100.0	95.05	100.0	100.0	99.91	96.86	100.0	100.0	100.0	100.0	100.0
840 μ	100.0	97.25	100.0	100.0	100.0	97.63	100.0	100.0	100.0	100.0	100.0
1000 μ (0 θ)	100.0	98.80	100.0	100.0	100.0	98.37	100.0	100.0	100.0	100.0	100.0
1190 μ	100.0	99.53	100.0	100.0	100.0	99.03	100.0	100.0	100.0	100.0	100.0
1410 μ	100.0	99.80	100.0	100.0	100.0	99.52	100.0	100.0	100.0	100.0	100.0
1680 μ	100.0	99.94	100.0	100.0	100.0	99.86	100.0	100.0	100.0	100.0	100.0
2000 μ (-1 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% grainsize											
clay (<4μ)	16.10	31.66	16.62	21.69	42.20	25.41	18.74	19.43	17.03	12.98	12.30
silt (4 - 63μ)	24.77	35.17	59.62	66.21	39.63	49.11	41.74	43.71	54.51	37.25	59.74
sand (63μ - 2 mm)	59.13	33.17	23.77	12.10	18.18	25.48	39.52	36.85	28.46	49.77	27.95

Drill hole and depth	AB02 10m	AB02 11m	AB02 12m	AB02 13m	AB02 14m	AB02 15m	AB02 16m	AB02 17m	AB02 18m	AB02 19m	AB02 20m
	2.10	1.96	2.84	2.44	1.75	1.92	2.33	1.46	1.52	1.67	2.31
50 percentile (μ)	40.98	43.23	39.89	70.65	35.82	60.70	38.61	55.68	64.73	53.17	159.24
90 percentile (μ)	229.94	235.89	205.20	355.79	267.48	346.11	295.49	335.20	334.82	308.69	452.98
Mode (μ)	107.36	109.10	97.54	121.55	83.18	226.81	40.13	247.92	245.94	145.06	311.99
Secondary modes (μ)	15.20	13.46	20.46	16.72	17.70	17.85	222.43	0.67	14.81	17.15	11.69
	0.68	0.73	0.72	0.83	0.73	0.72	0.74		0.71	0.73	0.65
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.00	0.03
0.49 μ (11 θ)	1.99	1.87	1.39	1.47	2.08	2.04	1.63	2.80	2.52	2.20	2.18
0.98 μ (10 θ)	5.70	5.80	4.48	4.78	6.32	5.95	5.06	7.40	7.11	6.53	5.63
2 μ (9 θ)	9.66	10.14	7.83	8.67	10.99	10.28	8.96	12.29	12.07	11.36	9.16
3.9 μ (8 θ)	14.96	15.81	12.35	13.53	16.92	15.63	13.93	18.01	17.91	17.31	13.40
7.8 μ (7 θ)	22.77	24.02	19.51	19.60	24.89	22.23	20.60	24.34	24.55	24.33	18.26
15.6 μ (6 θ)	34.18	35.04	31.20	27.63	35.76	30.78	30.93	32.37	32.36	32.89	23.61
31 μ (5 θ)	45.64	45.24	44.95	36.22	47.47	39.98	45.06	41.46	40.16	41.93	28.31
37 μ	48.37	47.69	48.48	38.57	50.58	42.39	49.04	43.88	42.17	44.35	29.51
44 μ	51.18	50.28	52.03	41.11	53.77	44.87	52.96	46.35	44.29	46.90	30.82
53 μ	54.53	53.47	56.10	44.22	57.42	47.73	57.14	49.20	46.84	49.94	32.45
62.5 μ (4 θ)	57.91	56.77	60.01	47.39	60.87	50.51	60.76	51.95	49.41	52.96	34.14
74 μ	61.83	60.68	64.35	51.04	64.56	53.62	64.35	55.00	52.39	56.37	36.13
88 μ	66.27	65.16	69.10	55.14	68.42	57.08	67.89	58.38	55.82	60.18	38.48
105 μ	71.08	70.04	74.08	59.56	72.31	60.87	71.33	62.06	59.64	64.30	41.24
125 μ (3 θ)	75.86	74.93	78.88	64.02	76.00	64.82	74.59	65.87	63.70	68.49	44.44
149 μ	80.47	79.66	83.34	68.50	79.50	68.99	77.77	69.88	68.03	72.75	48.31
177 μ	84.61	83.92	87.19	72.86	82.74	73.24	80.84	73.98	72.50	76.92	52.96
210 μ	88.26	87.70	90.40	77.16	85.81	77.59	83.91	78.22	77.15	81.05	58.57
250 μ (2 θ)	91.49	91.07	93.07	81.53	88.85	82.07	87.04	82.68	82.03	85.20	65.28
300 μ	94.35	94.09	95.31	86.03	91.90	86.65	90.26	87.31	87.10	89.37	73.08
350 μ	96.36	96.23	96.83	89.63	94.30	90.25	92.84	91.00	91.11	92.62	79.83
420 μ	98.23	98.24	98.25	93.44	96.76	93.94	95.54	94.79	95.17	95.89	87.27
500 μ (1 θ)	99.43	99.50	99.22	96.37	98.54	96.70	97.62	97.55	98.02	98.21	93.14
590 μ	99.99	99.99	99.78	98.36	99.60	98.52	99.02	99.22	99.59	99.54	97.11
710 μ	100.00	100.00	99.97	99.62	100.00	99.64	99.86	99.96	100.00	100.00	99.55
840 μ	100.00	100.00	100.00	99.94	100.00	99.92	100.00	100.00	100.00	100.00	100.00
1000 μ (0 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1190 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 μ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4μ)	14.96	15.81	12.35	13.53	16.92	15.63	13.93	18.01	17.91	17.31	13.40
silt (4 - 63μ)	42.95	40.96	47.66	33.86	43.95	34.88	46.83	33.94	31.50	35.65	20.74
sand (63μ - 2 mm)	42.09	43.23	39.99	52.61	39.13	49.49	39.24	48.05	50.59	47.04	65.86

Drill hole and depth	AB02 21m	AB02 22m	AB02 23m	AB02 24m	AB02 25m	AB03 1m	AB03 2m	AB03 3m	AB03 4m	AB03 5m	AB03 6m
10 percentile (µ)	4.81	36.67	28.03	14.54	7.47	3.65	3.02	2.65	3.92	11.12	2.15
50 percentile (µ)	228.92	254.18	245.15	158.95	153.84	24.35	25.54	22.24	39.25	186.34	23.42
90 percentile (µ)	476.78	513.45	485.33	498.07	437.92	97.57	105.67	92.70	225.87	461.88	262.30
Mode (µ)	306.74	311.35	295.20	282.07	237.63	30.51	33.57	28.21	61.43	297.87	19.24
Secondary modes (µ)	11.56		4.62	3.29	3.63	350.91	0.79	0.84	0.81	0.74	333.38
	0.65						350.33				0.72
Cumulative Volume											
0.12 µ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 µ (12 θ)	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 µ (11 θ)	1.47	0.39	0.19	0.30	0.66	0.38	0.82	0.95	0.77	0.47	1.59
0.98 µ (10 θ)	3.81	1.31	1.05	1.56	2.45	2.50	3.81	4.17	3.14	1.62	5.35
2 µ (9 θ)	6.20	2.33	2.39	3.28	4.64	5.41	7.21	7.99	5.92	2.95	9.48
3.9 µ (8 θ)	9.04	3.57	4.21	5.31	7.30	10.66	12.20	13.47	9.97	4.82	15.36
7.8 µ (7 θ)	12.34	5.03	6.24	7.44	10.19	20.03	20.56	22.89	17.05	7.79	24.89
15.6 µ (6 θ)	15.98	6.82	8.21	10.39	13.86	35.88	35.07	39.17	29.05	12.64	39.86
31 µ (5 θ)	19.44	9.22	10.36	16.05	18.61	58.37	56.57	60.79	44.32	19.36	56.77
37 µ	20.39	10.04	11.06	18.19	20.05	64.52	62.67	66.49	48.56	21.35	60.80
44 µ	21.38	10.95	11.80	20.61	21.66	70.33	68.53	71.88	52.83	23.38	64.53
53 µ	22.49	12.03	12.66	23.56	23.75	76.12	74.47	77.29	57.55	25.65	68.30
62.5 µ (4 θ)	23.49	13.10	13.51	26.50	26.08	80.73	79.22	81.66	61.78	27.73	71.40
74 µ	24.55	14.36	14.54	29.85	29.04	84.82	83.46	85.62	66.11	29.96	74.35
88 µ	25.78	15.97	15.94	33.67	32.80	88.29	87.05	89.09	70.45	32.42	77.11
105 µ	27.42	18.18	18.06	37.99	37.43	91.06	89.91	91.95	74.68	35.26	79.63
125 µ (3 θ)	29.80	21.29	21.26	42.72	42.76	93.08	91.99	94.12	78.61	38.64	81.84
149 µ	33.46	25.75	26.05	47.95	48.83	94.51	93.47	95.72	82.28	42.91	83.84
177 µ	38.71	31.77	32.59	53.54	55.33	95.48	94.51	96.83	85.64	48.19	85.68
210 µ	45.77	39.50	41.00	59.50	62.16	96.20	95.31	97.63	88.75	54.63	87.50
250 µ (2 θ)	54.72	49.03	51.21	65.89	69.30	96.84	96.05	98.25	91.66	62.31	89.44
300 µ	65.31	60.17	62.91	72.73	76.67	97.49	96.85	98.80	94.36	71.07	91.61
350 µ	74.44	69.82	72.75	78.43	82.55	98.07	97.54	99.22	96.29	78.47	93.51
420 µ	84.30	80.46	83.24	84.78	88.74	98.75	98.37	99.64	98.08	86.44	95.69
500 µ (1 θ)	91.83	88.91	91.19	90.11	93.55	99.32	99.07	99.92	99.23	92.58	97.53
590 µ	96.74	94.79	96.40	94.22	96.92	99.74	99.58	100.00	99.85	96.72	98.88
710 µ	99.61	98.81	99.51	97.54	99.28	99.98	99.90	100.00	100.00	99.39	99.79
840 µ	100.00	100.00	100.00	99.39	100.00	100.00	99.99	100.00	100.00	100.00	100.00
1000 µ (0 θ)	100.00	100.00	100.00	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1190 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 µ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4µ)	9.04	3.57	4.21	5.31	7.30	10.66	12.20	13.47	9.97	4.82	15.36
silt (4µ - 63µ)	14.45	9.53	9.30	21.18	18.78	70.06	67.02	68.19	51.82	22.91	56.04
sand (63µ - 2 mm)	76.51	86.90	86.49	73.50	73.92	19.27	20.78	18.34	38.22	72.27	28.60

Drill hole and depth	AB03 7m	AB03 8m	AB03 9m	AB03 10m	AB04 1m	AB04 2m	AB04 3m	AB04 4m	AB04 5m	AB04 6m	AB04 7m
10 percentile (μ)	1.76	2.58	2.66	2.75	1.16	1.38	1.94	2.70	2.07	1.41	1.59
50 percentile (μ)	78.72	40.91	53.17	55.29	33.82	22.14	26.61	46.11	20.18	23.84	61.96
90 percentile (μ)	344.52	320.17	248.82	365.63	318.36	237.87	257.34	399.50	228.31	311.12	441.21
Mode (μ)	235.52	247.90	92.41	188.26	136.62	15.06	15.20	288.16	15.86	269.65	335.62
Secondary modes (μ)	14.86	25.15	0.79	22.47	14.14	111.06	108.98	15.38	258.06	13.15	13.47
	0.65	78.90		0.62	2.68		0.87	0.72	0.71	0.67	0.67
		0.68			0.97						
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	2.48	1.65	1.40	1.93	2.02	1.64	1.38	1.38	1.60	2.46	2.42
0.98 μ (10 θ)	6.66	4.93	4.40	5.06	8.34	6.97	5.40	4.62	5.59	7.56	7.05
2 μ (9 θ)	10.82	8.38	8.06	8.16	15.61	13.72	10.26	8.08	9.74	12.55	11.55
3.9 μ (8 θ)	16.03	13.16	12.86	12.35	23.00	21.73	16.54	12.93	15.73	19.19	16.99
7.8 μ (7 θ)	22.39	20.31	18.79	18.34	30.75	31.08	25.55	20.82	26.18	29.02	24.34
15.6 μ (6 θ)	29.90	31.30	27.40	28.12	40.12	43.46	39.18	32.58	43.09	42.33	33.83
31 μ (5 θ)	37.43	44.61	38.62	40.66	48.99	55.62	52.68	44.33	60.33	53.88	42.51
37 μ	39.38	48.05	41.98	43.70	51.04	58.32	55.59	46.94	63.97	56.15	44.44
44 μ	41.39	51.41	45.60	46.49	53.09	60.89	58.32	49.36	67.20	58.21	46.28
53 μ	43.77	55.00	49.92	49.36	55.47	63.70	61.26	51.89	70.36	60.38	48.28
62.5 μ (4 θ)	46.15	58.20	54.17	51.89	57.84	66.31	63.99	54.13	72.95	62.36	50.10
74 μ	48.90	61.49	58.88	54.61	60.60	69.15	66.99	56.50	75.45	64.52	52.02
88 μ	52.12	64.87	63.96	57.68	63.78	72.27	70.29	59.04	77.90	66.92	54.04
105 μ	55.85	68.30	69.20	61.17	67.36	75.59	73.81	61.80	80.28	69.57	56.19
125 μ (3 θ)	60.00	71.66	74.22	64.97	71.10	78.90	77.32	64.73	82.52	72.38	58.45
149 μ	64.63	75.02	78.92	69.05	74.93	82.17	80.75	67.92	84.71	75.40	61.03
177 μ	69.60	78.33	83.09	73.19	78.64	85.22	83.91	71.34	86.83	78.56	64.06
210 μ	74.87	81.67	86.78	77.34	82.18	88.06	86.82	75.02	88.95	81.89	67.77
250 μ (2 θ)	80.40	85.14	90.08	81.51	85.61	90.75	89.56	79.04	91.15	85.45	72.35
300 μ	86.05	88.75	93.07	85.73	88.96	93.32	92.22	83.39	93.47	89.25	77.88
350 μ	90.42	91.66	95.23	89.10	91.59	95.29	94.30	87.04	95.35	92.35	82.86
420 μ	94.73	94.74	97.29	92.67	94.40	97.28	96.48	91.05	97.32	95.60	88.57
500 μ (1 θ)	97.71	97.12	98.74	95.52	96.67	98.73	98.18	94.34	98.76	97.99	93.29
590 μ	99.40	98.74	99.59	97.57	98.32	99.61	99.30	96.79	99.63	99.41	96.70
710 μ	100.00	99.76	99.97	99.09	99.46	99.99	99.90	98.66	99.98	99.99	99.12
840 μ	100.00	99.99	100.00	99.79	99.89	100.00	100.00	99.55	100.00	100.00	99.94
1000 μ (0 θ)	100.00	100.00	100.00	99.98	100.00	100.00	100.00	99.89	100.00	100.00	100.00
1190 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 μ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4μ)	16.03	13.16	12.86	12.35	23.00	21.73	16.54	12.93	15.73	19.19	16.99
silt (4μ - 63μ)	30.12	45.04	41.31	39.54	34.85	44.57	47.45	41.20	57.22	43.17	33.10
sand (63μ - 2 mm)	53.85	41.80	45.83	48.11	42.16	33.69	36.01	45.87	27.05	37.64	49.90

Drill hole and depth	AB04 8m	AB04 9m	AB04 10m	AB04 11m	AB04 12m	AB04 13m	AB04 14m	AB04 15m	AB04 16m	AB05A 1m	AB05A 2m
10 percentile (µ)	1.91	0.93	1.03	1.48	1.64	1.39	1.64	0.88	0.78	1.62	4.23
50 percentile (µ)	29.35	14.09	16.71	16.50	23.54	16.21	17.84	10.63	8.48	34.35	94.53
90 percentile (µ)	324.19	296.02	303.93	256.15	338.69	102.26	150.59	126.36	189.16	286.81	302.65
Mode (µ)	16.39	319.83	297.75	15.26	310.91	19.22	19.69	12.79	10.00	134.53	185.24
Secondary modes (µ)	301.31	11.06	10.63	320.78	15.40	0.73	310.13	0.71	0.73	15.54	20.49
	76.12	78.46	0.74	0.79	0.69	334.69	0.76	292.20	295.59	0.72	
	0.76	0.74									
Cumulative Volume											
0.12 µ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 µ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 µ (11 θ)	1.61	3.12	2.96	2.01	2.21	2.24	1.75	3.55	4.24	2.14	0.45
0.98 µ (10 θ)	5.77	10.56	9.55	6.86	6.71	7.40	6.35	11.18	12.90	6.72	2.41
2 µ (9 θ)	10.36	18.65	16.82	12.75	11.45	13.09	11.67	19.31	22.43	11.52	5.24
3.9 µ (8 θ)	16.27	28.45	25.90	20.84	17.77	20.71	18.99	29.73	34.13	17.55	9.41
7.8 µ (7 θ)	24.86	39.60	36.89	32.14	27.34	32.00	29.93	43.02	48.19	25.88	15.17
15.6 µ (6 θ)	37.63	51.73	48.90	48.56	41.30	48.94	46.36	59.10	63.06	37.07	22.93
31 µ (5 θ)	50.98	61.29	58.22	64.73	55.19	67.92	64.89	73.38	74.30	48.41	31.55
37 µ	54.02	63.32	60.19	68.08	58.17	72.40	69.34	76.41	76.51	51.14	33.77
44 µ	56.87	65.27	62.11	71.03	60.84	76.47	73.42	79.13	78.49	53.82	36.02
53 µ	59.87	67.42	64.24	73.88	63.43	80.41	77.40	81.77	80.43	56.80	38.62
62.5 µ (4 θ)	62.51	69.39	66.23	76.14	65.49	83.48	80.50	83.85	81.99	59.59	41.23
74 µ	65.21	71.47	68.38	78.20	67.41	86.17	83.21	85.72	83.43	62.63	44.36
88 µ	67.98	73.62	70.68	80.04	69.18	88.43	85.48	87.34	84.75	65.95	48.20
105 µ	70.80	75.77	73.07	81.68	70.86	90.24	87.31	88.74	85.96	69.52	52.89
125 µ (3 θ)	73.54	77.84	75.46	83.11	72.53	91.60	88.73	89.93	87.08	73.15	58.32
149 µ	76.30	79.91	77.92	84.49	74.43	92.67	89.93	91.03	88.23	76.84	64.49
177 µ	79.07	82.03	80.47	85.94	76.71	93.55	91.05	92.13	89.47	80.42	70.99
210 µ	81.96	84.36	83.22	87.63	79.54	94.40	92.25	93.31	90.89	83.92	77.55
250 µ (2 θ)	85.09	87.07	86.30	89.69	83.04	95.36	93.65	94.64	92.52	87.38	83.91
300 µ	88.52	90.24	89.75	92.15	87.17	96.47	95.27	96.12	94.36	90.83	89.75
350 µ	91.44	93.03	92.66	94.34	90.76	97.48	96.68	97.36	95.91	93.55	93.75
420 µ	94.65	96.08	95.77	96.74	94.65	98.62	98.19	98.66	97.57	96.37	97.21
500 µ (1 θ)	97.21	98.32	98.07	98.55	97.58	99.48	99.29	99.54	98.81	98.45	99.23
590 µ	98.91	99.58	99.43	99.62	99.34	99.97	99.87	99.96	99.59	99.67	99.99
710 µ	99.85	100.00	99.99	100.00	100.00	100.00	100.00	100.00	99.94	100.00	100.00
840 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1000 µ (0 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1190 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 µ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4µ))	16.27	28.45	25.90	20.84	17.77	20.71	18.99	29.73	34.13	17.55	9.41
silt (4µ - 63µ)	46.24	40.94	40.33	55.30	47.73	62.78	61.51	54.12	47.86	42.04	31.82
sand (63µ - 2 mm)	37.49	30.61	33.77	23.86	34.51	16.52	19.50	16.15	18.01	40.41	58.77

Drill hole and depth	AB05A 3m	AB05B 4m	AB05B 5m	AB05B 6m	AB05A 7m	AB05A 8m	AB05A 9m	AB05A 10m	AB05A 11m	AB05A 12m	AB05A 13m
10 percentile (μ)	5.03	8.63	9.44	5.62	11.39	8.60	3.35	3.88	5.11	4.05	3.44
50 percentile (μ)	80.16	149.47	186.78	97.94	186.22	251.82	47.52	61.04	147.18	87.56	37.99
90 percentile (μ)	255.76	425.68	427.26	305.20	383.47	794.86	262.36	305.77	382.55	495.24	250.63
Mode (μ)	145.31	250.43	255.34	166.78	218.02	414.53	95.30	136.22	238.04	106.43	100.46
Secondary modes (μ)			32.74		16.15	16.35		18.78	16.51	14.31	18.16
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	0.33	0.12	0.13	0.43	0.21	0.23	0.50	0.46	0.37	0.39	0.50
0.98 μ (10 θ)	1.97	1.15	1.23	2.22	1.20	1.34	2.92	2.64	2.11	2.44	2.77
2 μ (9 θ)	4.51	2.91	3.10	4.62	2.70	2.98	6.40	5.68	4.68	5.57	6.02
3.9 μ (8 θ)	8.26	5.61	5.69	7.88	4.90	5.45	11.26	10.05	8.26	9.73	11.12
7.8 μ (7 θ)	13.47	9.35	8.96	12.17	8.01	9.32	18.56	16.91	13.09	15.35	19.36
15.6 μ (6 θ)	20.93	14.58	13.20	18.34	11.76	14.75	29.22	26.94	19.14	22.36	32.02
31 μ (5 θ)	30.74	21.31	18.58	26.84	15.34	20.35	41.48	37.97	25.36	29.71	46.05
37 μ	33.58	23.26	20.06	29.38	15.96	21.66	44.86	40.85	26.90	31.97	49.49
44 μ	36.55	25.28	21.50	32.06	16.40	22.90	48.36	43.79	28.43	34.56	52.87
53 μ	40.07	27.64	23.01	35.24	16.78	24.21	52.41	47.19	30.16	37.90	56.60
62.5 μ (4 θ)	43.61	29.97	24.40	38.45	17.27	25.42	56.28	50.49	31.88	41.40	60.10
74 μ	47.79	32.67	26.00	42.26	18.28	26.78	60.51	54.20	33.98	45.50	63.90
88 μ	52.77	35.92	28.09	46.82	20.36	28.41	65.03	58.37	36.67	50.14	68.00
105 μ	58.57	39.85	31.04	52.21	24.09	30.46	69.72	62.94	40.23	55.13	72.30
125 μ (3 θ)	64.89	44.45	35.10	58.22	29.75	32.99	74.25	67.67	44.74	60.07	76.50
149 μ	71.57	49.89	40.65	64.77	37.56	36.17	78.58	72.51	50.43	64.86	80.51
177 μ	78.07	56.00	47.56	71.42	46.98	39.99	82.49	77.18	57.09	69.22	84.08
210 μ	84.07	62.70	55.69	77.90	57.41	44.49	86.00	81.60	64.54	73.18	87.20
250 μ (2 θ)	89.38	69.92	64.78	84.01	68.25	49.77	89.19	85.76	72.54	76.89	89.96
300 μ	93.80	77.46	74.38	89.54	78.75	55.93	92.10	89.63	80.69	80.54	92.44
350 μ	96.58	83.44	81.89	93.32	86.29	61.50	94.24	92.45	86.89	83.52	94.27
420 μ	98.78	89.60	89.39	96.68	93.12	68.33	96.35	95.20	92.85	86.98	96.16
500 μ (1 θ)	99.91	94.23	94.75	98.76	97.47	74.84	97.94	97.23	96.89	90.17	97.68
590 μ	100.00	97.35	98.11	99.79	99.68	80.76	99.02	98.62	99.19	92.99	98.83
710 μ	100.00	99.39	99.86	100.00	100.00	86.78	99.74	99.60	100.00	95.74	99.67
840 μ	100.00	99.94	100.00	100.00	100.00	91.43	99.96	99.95	100.00	97.69	99.95
1000 μ (0 θ)	100.00	100.00	100.00	100.00	100.00	95.23	100.00	100.00	100.00	99.08	100.00
1190 μ	100.00	100.00	100.00	100.00	100.00	97.91	100.00	100.00	100.00	99.83	100.00
1410 μ	100.00	100.00	100.00	100.00	100.00	99.49	100.00	100.00	100.00	99.99	100.00
1680 μ	100.00	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00	100.00	100.00
2000 μ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4μ))	8.26	5.61	5.69	7.88	4.90	5.45	11.26	10.05	8.26	9.73	11.12
silt (4μ - 63μ)	35.35	24.35	18.71	30.58	12.37	19.97	45.03	40.44	23.63	31.67	48.97
sand (63μ - 2 mm)	56.39	70.03	75.60	61.55	82.73	74.58	43.72	49.51	68.12	58.60	39.90

Drill hole and depth	AB05A 14m	AB05A 15m	AB05A 16m	AB05A 17m	AB05A 18m	AB05A 19m	AB05A 20m	AB05A 21m	AB05A 22m	AB05A 23m	AB05A 24m
10 percentile (μ)	4.34	5.09	5.20	3.75	3.16	3.63	3.78	4.03	3.47	3.32	3.29
50 percentile (μ)	46.28	32.17	139.43	50.61	58.11	45.09	47.57	57.88	43.35	44.56	34.90
90 percentile (μ)	204.21	105.36	425.94	262.87	365.54	174.24	162.08	195.04	162.08	164.86	145.14
Mode (μ)	110.91	53.22	262.00	96.26	108.23	95.67	101.19	115.11	99.17	97.60	80.78
Secondary modes (μ)	20.29	0.85	16.69	14.26	0.78	0.78	16.94	16.09	15.68	16.44	17.19
	0.84	396.79					0.86				
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	0.62	0.37	0.32	0.54	0.80	0.86	0.71	0.64	0.70	0.81	0.69
0.98 μ (10 θ)	2.73	2.16	2.00	2.83	3.40	3.38	3.08	2.86	3.18	3.42	3.28
2 μ (9 θ)	5.30	4.36	4.70	5.86	6.79	6.31	5.97	5.64	6.33	6.65	6.58
3.9 μ (8 θ)	9.18	7.86	8.28	10.33	11.80	10.54	10.24	9.75	10.98	11.33	11.48
7.8 μ (7 θ)	16.14	15.04	12.61	17.72	19.49	17.68	17.53	16.64	18.89	18.98	20.00
15.6 μ (6 θ)	27.97	29.01	17.71	28.75	29.90	29.04	29.02	27.19	30.98	30.51	33.12
31 μ (5 θ)	41.85	48.79	23.15	40.58	40.05	42.08	41.49	38.29	43.58	42.85	47.42
37 μ	45.39	54.74	24.79	43.74	42.58	45.65	44.76	41.14	46.84	46.16	51.32
44 μ	48.93	60.89	26.64	47.08	45.19	49.43	48.26	44.17	50.31	49.72	55.47
53 μ	52.97	67.74	29.00	51.02	48.31	53.98	52.62	47.95	54.59	54.12	60.41
62.5 μ (4 θ)	56.87	73.81	31.48	54.87	51.42	58.51	57.15	51.94	59.01	58.63	65.22
74 μ	61.27	79.76	34.46	59.14	54.98	63.65	62.51	56.75	64.17	63.86	70.50
88 μ	66.19	85.26	38.00	63.77	58.98	69.33	68.65	62.43	70.01	69.73	76.05
105 μ	71.53	89.92	42.15	68.58	63.27	75.27	75.25	68.79	76.24	75.94	81.53
125 μ (3 θ)	76.88	93.41	46.80	73.24	67.53	80.93	81.67	75.30	82.25	81.89	86.42
149 μ	82.06	95.81	52.06	77.71	71.70	86.09	87.53	81.64	87.70	87.29	90.56
177 μ	86.68	97.24	57.78	81.80	75.57	90.35	92.31	87.23	92.15	91.70	93.71
210 μ	90.59	98.03	63.99	85.55	79.18	93.69	95.92	91.89	95.53	95.08	95.98
250 μ (2 θ)	93.80	98.48	70.70	89.06	82.69	96.20	98.44	95.56	97.94	97.53	97.55
300 μ	96.33	98.81	77.80	92.34	86.25	97.99	99.82	98.23	99.47	99.15	98.60
350 μ	97.88	99.08	83.55	94.75	89.19	99.00	100.00	99.62	99.92	99.88	99.19
420 μ	99.08	99.44	89.58	97.08	92.50	99.68	100.00	99.99	100.00	100.00	99.65
500 μ (1 θ)	99.62	99.75	94.20	98.68	95.32	99.96	100.00	100.00	100.00	100.00	99.89
590 μ	99.82	99.97	97.35	99.62	97.48	100.00	100.00	100.00	100.00	100.00	100.00
710 μ	99.95	100.00	99.45	99.98	99.14	100.00	100.00	100.00	100.00	100.00	100.00
840 μ	100.00	100.00	100.00	100.00	99.85	100.00	100.00	100.00	100.00	100.00	100.00
1000 μ (0 θ)	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00	100.00	100.00	100.00
1190 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 μ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4μ))	9.18	7.86	8.28	10.33	11.80	10.54	10.24	9.75	10.98	11.33	11.48
silt (4μ - 63μ)	47.70	65.96	23.20	44.54	39.62	47.97	46.91	42.19	48.02	47.30	53.74
sand (63μ - 2 mm)	43.13	26.19	68.52	45.13	48.58	41.49	42.85	48.06	40.99	41.37	34.78

Drill hole and depth	AB05A 25m	AB05A 26m	AB05A 27m	AB05A 28m	AB05A 29m	AB05A 30m	AB05A 31m	AB05A 32m	AB05A 33m	AB05A 34m	AB05A 35m
10 percentile (µ)	3.64	5.06	3.46	3.41	1.91	1.33	2.08	3.19	1.87	3.95	3.17
50 percentile (µ)	31.32	103.32	36.83	27.94	18.54	10.54	16.85	26.31	19.74	80.12	40.92
90 percentile (µ)	129.65	425.74	202.13	145.31	150.49	41.94	128.49	131.13	137.80	412.29	160.15
Mode (µ)	65.30	261.88	96.26	72.39	14.36	14.45	17.89	29.03	20.47	143.78	78.44
Secondary modes (µ)		18.14	20.04	19.76	103.35					16.57	
			0.86		0.76						
Cumulative Volume											
0.12 µ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 µ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 µ (11 θ)	0.71	0.45	0.76	0.60	1.51	1.71	0.92	0.59	1.11	0.60	0.44
0.98 µ (10 θ)	3.16	2.30	3.31	3.12	5.63	7.25	4.54	3.25	5.12	2.82	2.92
2 µ (9 θ)	6.19	4.72	6.42	6.30	10.38	14.54	9.62	6.71	10.62	5.77	6.70
3.9 µ (8 θ)	10.55	8.20	10.99	11.18	17.34	25.07	17.22	11.77	18.23	9.91	11.72
7.8 µ (7 θ)	18.08	13.78	18.89	20.05	28.63	40.91	29.00	20.37	29.00	16.15	19.05
15.6 µ (6 θ)	31.74	22.19	31.69	35.13	45.57	63.22	47.61	35.26	44.17	25.16	30.15
31 µ (5 θ)	49.71	31.42	46.36	52.59	61.25	83.84	68.05	54.83	61.14	34.65	43.56
37 µ	54.63	33.72	50.10	56.96	64.35	87.68	72.39	60.01	65.34	36.99	47.54
44 µ	59.57	35.99	53.82	61.21	67.17	90.80	76.08	64.98	69.32	39.37	51.87
53 µ	65.02	38.53	57.96	65.85	70.16	93.51	79.44	70.13	73.42	42.17	57.10
62.5 µ (4 θ)	69.96	40.95	61.82	70.03	72.92	95.42	81.97	74.48	76.86	44.99	62.22
74 µ	75.05	43.67	65.97	74.39	75.96	96.96	84.20	78.66	80.17	48.29	67.80
88 µ	80.14	46.78	70.39	78.83	79.34	98.16	86.22	82.60	83.32	52.14	73.63
105 µ	84.99	50.34	74.97	83.16	82.96	99.03	88.07	86.19	86.21	56.49	79.33
125 µ (3 θ)	89.21	54.29	79.41	87.06	86.51	99.58	89.75	89.25	88.74	61.07	84.35
149 µ	92.70	58.72	83.64	90.44	89.83	99.88	91.32	91.81	90.93	65.81	88.55
177 µ	95.33	63.50	87.40	93.14	92.65	100.00	92.75	93.85	92.76	70.44	91.74
210 µ	97.21	68.61	90.69	95.22	94.92	100.00	94.09	95.48	94.29	74.90	94.08
250 µ (2 θ)	98.48	74.09	93.54	96.80	96.68	100.00	95.36	96.80	95.61	79.24	95.78
300 µ	99.32	79.88	95.96	97.99	98.01	100.00	96.59	97.89	96.77	83.49	97.06
350 µ	99.75	84.60	97.56	98.73	98.81	100.00	97.54	98.64	97.60	86.81	97.89
420 µ	99.97	89.66	98.93	99.35	99.46	100.00	98.53	99.32	98.43	90.34	98.69
500 µ (1 θ)	100.00	93.69	99.71	99.73	99.85	100.00	99.30	99.78	99.06	93.23	99.30
590 µ	100.00	96.61	99.97	99.93	100.00	100.00	99.80	99.99	99.51	95.49	99.72
710 µ	100.00	98.80	100.00	100.00	100.00	100.00	100.00	100.00	99.80	97.43	99.97
840 µ	100.00	99.79	100.00	100.00	100.00	100.00	100.00	100.00	99.92	98.66	100.00
1000 µ (0 θ)	100.00	99.99	100.00	100.00	100.00	100.00	100.00	100.00	99.99	99.47	100.00
1190 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.84	100.00
1410 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00
1680 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 µ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4µ)	10.55	8.20	10.99	11.18	17.34	25.07	17.22	11.77	18.23	9.91	11.72
silt (4µ - 63µ)	59.42	32.75	50.82	58.85	55.57	70.35	64.75	62.71	58.63	35.08	50.49
sand (63µ - 2 mm)	30.04	59.05	38.18	29.97	27.08	4.58	18.03	25.52	23.14	55.01	37.78

Drill hole and depth	AB06B 3m	AB06B 4m	AB06B 5m	AB06B 6m	AB06B 7m	AB06B 8m	AB06B 9m	AB06B 10m	AB06B 11m	AB06B 12m	AB06B 13m
10 percentile (μ)	1.56	1.78	2.35	1.67	6.09	5.03	2.70	3.32	4.37	4.51	3.39
50 percentile (μ)	12.63	15.85	36.47	14.25	52.67	28.56	33.98	29.10	45.80	29.20	29.79
90 percentile (μ)	97.48	209.32	204.75	61.05	481.46	196.00	239.24	143.90	245.46	153.85	173.84
Mode (μ)	13.24	15.57	45.42	22.30	42.23	29.28	45.83	29.84	79.16	29.94	34.06
Secondary modes (μ)											
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	1.67	1.32	1.53	1.21	0.30	0.32	1.24	0.84	0.68	0.46	0.50
0.98 μ (10 θ)	6.48	5.60	4.96	5.62	1.80	2.06	4.40	3.49	2.83	2.46	2.86
2 μ (9 θ)	12.32	11.08	8.92	11.88	3.98	4.42	8.02	6.64	5.41	4.90	6.25
3.9 μ (8 θ)	21.36	19.04	13.77	21.21	7.19	8.10	12.85	11.35	9.19	8.81	11.19
7.8 μ (7 θ)	36.09	31.36	19.73	34.58	11.93	14.56	20.31	19.48	15.42	16.28	18.77
15.6 μ (6 θ)	56.44	49.55	29.31	52.57	20.11	28.86	32.59	33.59	26.12	30.85	31.93
31 μ (5 θ)	74.05	67.45	45.33	72.49	34.93	53.15	47.91	51.71	40.71	51.95	51.21
37 μ	77.34	70.96	50.43	77.49	39.86	59.83	51.94	56.50	44.85	57.66	56.65
44 μ	80.15	73.87	55.62	82.17	44.87	65.97	55.88	61.17	49.02	63.08	61.90
53 μ	82.81	76.49	61.22	86.83	50.17	71.86	60.12	66.16	53.62	68.56	67.31
62.5 μ (4 θ)	84.95	78.47	66.04	90.49	54.56	76.29	63.86	70.54	57.78	73.04	71.77
74 μ	86.99	80.26	70.70	93.67	58.56	79.99	67.65	74.97	62.11	77.19	75.93
88 μ	88.93	81.95	75.07	96.24	62.00	82.93	71.45	79.37	66.58	80.97	79.71
105 μ	90.74	83.60	79.02	98.10	64.81	85.15	75.18	83.57	71.08	84.31	83.02
125 μ (3 θ)	92.33	85.21	82.44	99.24	67.02	86.76	78.66	87.33	75.41	87.15	85.80
149 μ	93.71	86.84	85.43	99.82	68.94	88.05	81.95	90.61	79.58	89.59	88.17
177 μ	94.83	88.44	88.01	100.00	70.85	89.24	85.01	93.27	83.43	91.67	90.20
210 μ	95.75	90.03	90.33	100.00	73.08	90.56	87.89	95.39	87.00	93.50	92.03
250 μ (2 θ)	96.55	91.65	92.49	100.00	75.90	92.14	90.69	97.04	90.33	95.17	93.76
300 μ	97.28	93.30	94.54	100.00	79.46	94.01	93.42	98.32	93.40	96.71	95.46
350 μ	97.86	94.64	96.09	100.00	82.85	95.67	95.49	99.08	95.59	97.81	96.78
420 μ	98.51	96.12	97.63	100.00	87.01	97.49	97.54	99.68	97.64	98.85	98.12
500 μ (1 θ)	99.08	97.38	98.77	100.00	90.79	98.88	98.97	99.95	99.01	99.54	99.11
590 μ	99.54	98.38	99.50	100.00	93.92	99.71	99.76	100.00	99.76	99.91	99.72
710 μ	99.89	99.24	99.92	100.00	96.68	100.00	100.00	100.00	100.00	100.00	100.00
840 μ	100.00	99.74	100.00	100.00	98.44	100.00	100.00	100.00	100.00	100.00	100.00
1000 μ (0 θ)	100.00	99.96	100.00	100.00	99.48	100.00	100.00	100.00	100.00	100.00	100.00
1190 μ	100.00	100.00	100.00	100.00	99.88	100.00	100.00	100.00	100.00	100.00	100.00
1410 μ	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00	100.00	100.00	100.00
1680 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 μ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4μ)	21.36	19.04	13.77	21.21	7.19	8.10	12.85	11.35	9.19	8.81	11.19
silt (4μ - 63μ)	63.59	59.43	52.27	69.28	47.37	68.18	51.01	59.20	48.59	64.23	60.58
sand (63μ - 2 mm)	15.05	21.53	33.96	9.51	45.44	23.71	36.14	29.46	42.22	26.96	28.23

Drill hole and depth	AB06B 14m	AB06B 15m	AB06B 16m	AB06B 17m	AB06B 18m	AB07 1m	AB07 2m	AB07 3m	AB07 4m	AB07 5m	AB07 6m
10 percentile (µ)	3.19	3.38	2.61	3.05	4.67	2.47	3.72	3.33	6.72	8.97	7.41
50 percentile (µ)	26.89	25.86	20.91	17.62	33.87	26.14	29.64	28.67	72.34	96.29	63.46
90 percentile (µ)	229.12	198.47	187.41	105.85	217.45	268.28	146.08	166.52	252.02	316.12	230.76
Mode (µ)	21.75	25.23	19.61	18.40	34.44	18.62	24.56	20.56	146.07	190.79	103.77
Secondary modes (µ)						282.89	61.54	85.65			
						0.78					
Cumulative Volume											
0.12 µ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 µ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 µ (11 θ)	0.48	0.49	0.79	0.56	0.44	1.07	0.54	0.29	0.15	0.30	0.15
0.98 µ (10 θ)	2.91	2.87	3.88	3.17	2.37	4.60	2.81	2.23	1.38	1.52	1.34
2 µ (9 θ)	6.47	6.18	7.91	6.69	4.83	8.52	5.78	5.66	3.27	3.07	3.12
3.9 µ (8 θ)	11.88	11.30	14.01	12.56	8.62	13.88	10.40	11.68	6.34	5.38	5.91
7.8 µ (7 θ)	20.78	19.97	24.43	23.95	15.38	22.69	18.53	21.16	11.27	9.01	10.42
15.6 µ (6 θ)	35.63	35.21	41.48	45.41	28.22	37.31	32.95	35.39	19.57	15.26	18.51
31 µ (5 θ)	53.69	55.44	61.12	70.16	47.31	53.95	51.21	51.84	31.47	25.19	31.33
37 µ	58.10	60.57	65.66	75.20	52.69	57.84	55.92	55.92	34.92	28.33	35.40
44 µ	62.19	65.29	69.73	79.30	57.90	61.41	60.52	59.85	38.44	31.63	39.72
53 µ	66.30	69.89	73.62	82.80	63.29	65.03	65.45	64.09	42.46	35.42	44.74
62.5 µ (4 θ)	69.69	73.51	76.65	85.20	67.77	68.04	69.83	67.89	46.30	39.03	49.54
74 µ	72.93	76.77	79.37	87.12	71.98	70.96	74.31	71.88	50.61	43.02	54.79
88 µ	76.00	79.67	81.80	88.67	75.84	73.78	78.81	76.04	55.51	47.50	60.46
105 µ	78.92	82.25	83.97	89.95	79.29	76.48	83.15	80.26	61.03	52.53	66.40
125 µ (3 θ)	81.60	84.52	85.89	91.03	82.27	78.99	87.01	84.24	66.92	57.99	72.25
149 µ	84.15	86.65	87.69	92.04	84.91	81.43	90.35	87.91	73.10	63.96	77.94
177 µ	86.55	88.66	89.42	93.02	87.29	83.82	93.00	91.06	79.11	70.15	83.12
210 µ	88.85	90.66	91.16	94.02	89.55	86.28	95.07	93.67	84.74	76.43	87.73
250 µ (2 θ)	91.12	92.68	92.96	95.07	91.78	88.91	96.65	95.79	89.79	82.63	91.75
300 µ	93.36	94.72	94.82	96.18	94.02	91.74	97.87	97.48	94.06	88.49	95.12
350 µ	95.09	96.29	96.30	97.09	95.77	94.09	98.64	98.52	96.77	92.66	97.28
420 µ	96.85	97.86	97.85	98.07	97.54	96.57	99.31	99.34	98.91	96.42	99.01
500 µ (1 θ)	98.19	98.98	98.99	98.87	98.83	98.42	99.73	99.76	99.97	98.78	99.93
590 µ	99.12	99.66	99.70	99.45	99.62	99.53	99.96	99.97	100.00	99.93	100.00
710 µ	99.77	99.98	100.00	99.86	99.98	100.00	100.00	100.00	100.00	100.00	100.00
840 µ	99.98	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1000 µ (0 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1190 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 µ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4µ)	11.88	11.30	14.01	12.56	8.62	13.88	10.40	11.68	6.34	5.38	5.91
silt (4µ - 63µ)	57.81	62.21	62.64	72.64	59.15	54.16	59.43	56.21	39.95	33.64	43.63
sand (63µ - 2 mm)	30.31	26.49	23.35	14.80	32.23	31.96	30.17	32.11	53.70	60.97	50.46

Drill hole and depth	AB07 7m	AB07 8m	AB07 9m	AB08 1m	AB08 2m	AB08 3m	AB08 4m	AB08 5m	AB08 6m	AB08 7m	AB08 8m
10 percentile (μ)	7.32	6.03	12.03	1.70	1.73	1.99	2.28	3.01	2.72	3.30	3.22
50 percentile (μ)	77.97	71.36	276.58	10.85	10.75	14.89	17.10	21.03	20.17	24.77	23.95
90 percentile (μ)	295.03	502.87	621.59	199.62	136.78	59.79	72.12	71.39	74.65	93.58	85.02
Mode (μ)	170.15	374.22	418.17	11.25	11.70	20.49	21.44	29.39	27.12	33.65	33.61
Secondary modes (μ)		33.03	46.46	169.77	129.29		398.57			328.93	405.72
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	0.12	0.24	0.21	0.68	0.57	0.67	0.64	0.52	0.58	0.54	0.58
0.98 μ (10 θ)	1.20	1.60	1.09	4.77	4.46	4.20	3.83	3.05	3.31	2.95	3.09
2 μ (9 θ)	2.98	3.69	2.30	12.17	11.99	10.03	8.74	6.69	7.36	6.25	6.45
3.9 μ (8 θ)	5.89	7.01	4.18	24.19	24.20	19.21	16.46	12.66	13.86	11.56	11.82
7.8 μ (7 θ)	10.53	12.23	7.15	40.70	40.92	32.41	28.43	22.80	24.42	20.43	20.89
15.6 μ (6 θ)	18.53	21.13	12.17	60.25	60.73	51.46	47.08	40.22	41.86	35.69	36.57
31 μ (5 θ)	30.34	34.06	19.16	73.07	75.56	73.28	69.21	63.69	64.42	57.74	58.98
37 μ	33.76	37.67	21.16	74.58	77.83	78.44	74.52	69.95	70.29	63.96	65.26
44 μ	37.22	41.15	23.17	75.63	79.59	83.08	79.32	75.88	75.83	69.93	71.30
53 μ	41.09	44.73	25.34	76.53	81.17	87.50	83.92	81.84	81.39	76.00	77.46
62.5 μ (4 θ)	44.72	47.73	27.22	77.34	82.47	90.84	87.42	86.61	85.84	80.87	82.43
74 μ	48.70	50.60	29.04	78.35	83.86	93.68	90.42	90.84	89.81	85.22	86.90
88 μ	53.15	53.34	30.75	79.70	85.43	95.94	92.84	94.36	93.16	88.90	90.68
105 μ	58.09	55.96	32.32	81.47	87.19	97.58	94.66	97.01	95.74	91.78	93.65
125 μ (3 θ)	63.35	58.49	33.80	83.56	89.04	98.61	95.88	98.73	97.47	93.83	95.71
149 μ	68.94	61.12	35.51	85.92	90.90	99.16	96.64	99.65	98.47	95.23	97.03
177 μ	74.57	63.96	37.81	88.33	92.61	99.38	97.10	100.00	98.92	96.15	97.76
210 μ	80.11	67.22	41.21	90.69	94.13	99.43	97.41	100.00	99.07	96.82	98.17
250 μ (2 θ)	85.46	71.09	46.25	92.98	95.48	99.46	97.71	100.00	99.12	97.41	98.43
300 μ	90.42	75.74	53.45	95.17	96.70	99.52	98.11	100.00	99.21	98.03	98.70
350 μ	93.92	80.01	60.90	96.81	97.61	99.60	98.51	100.00	99.35	98.56	98.97
420 μ	97.06	85.18	70.67	98.39	98.56	99.74	99.05	100.00	99.59	99.16	99.34
500 μ (1 θ)	99.02	89.86	80.00	99.45	99.31	99.87	99.54	100.00	99.83	99.63	99.69
590 μ	99.99	93.70	87.85	99.96	99.81	99.96	99.88	100.00	99.99	99.92	99.93
710 μ	100.00	97.00	94.57	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
840 μ	100.00	98.96	98.40	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1000 μ (0 θ)	100.00	99.90	99.96	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1190 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 μ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4μ)	5.89	7.01	4.18	24.19	24.20	19.21	16.46	12.66	13.86	11.56	11.82
silt (4μ - 63μ)	38.83	40.72	23.04	53.15	58.27	71.63	70.96	73.95	71.98	69.32	70.61
sand (63μ - 2 mm)	55.28	52.27	72.78	22.66	17.53	9.16	12.58	13.39	14.16	19.13	17.57

Drill hole and depth	AB08 9m	AB08 10m	AB08 11m	AB08 12m	AB08 13m	AB08 14m	AB08 15m	AB09 1m	AB09 2m	AB09 3m	AB09 4m
10 percentile (μ)	2.08	3.70	1.99	1.47	1.53	1.85	2.44	0.88	1.68	1.75	1.47
50 percentile (μ)	18.35	30.27	17.71	10.25	10.22	19.91	41.96	13.05	14.36	12.06	9.27
90 percentile (μ)	102.7	144.6	85.08	49.88	61.53	256.8	206.1	212.4	98.14	47.89	42.29
Mode (μ)	21.36	35.43	22.31	15.32	15.41	219.2	110.8	191.6	16.13	14.82	11.37
Secondary modes	374.8		411.0		4.49	3.32		2.85		449.6	534.3
					397.2	11.49		14.04			
								0.82			
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	0.75	0.47	0.76	1.09	0.65	0.34	0.40	2.59	1.33	1.19	1.64
0.98 μ (10 θ)	4.22	2.66	4.38	5.82	5.09	3.46	3.11	11.56	5.75	5.48	6.64
2 μ (9 θ)	9.59	5.77	10.04	14.36	14.19	11.12	8.12	21.48	11.75	11.34	13.35
3.9 μ (8 θ)	17.63	10.43	18.31	27.16	28.00	22.90	14.95	32.14	20.60	20.42	24.63
7.8 μ (7 θ)	29.01	17.61	29.66	42.89	43.59	34.74	22.65	42.28	33.68	35.74	43.92
15.6 μ (6 θ)	45.49	30.58	46.37	62.01	60.68	46.20	32.24	52.79	52.46	59.53	69.01
31 μ (5 θ)	64.67	50.78	66.43	80.62	77.42	56.16	44.12	62.44	71.50	81.75	86.36
37 μ	69.36	56.62	71.37	84.51	81.17	58.47	47.50	64.42	75.44	85.69	88.68
44 μ	73.72	62.30	75.95	87.87	84.53	60.72	50.97	66.16	78.84	88.75	90.33
53 μ	78.08	68.16	80.52	90.94	87.74	63.21	54.96	67.88	82.02	91.30	91.62
62.5 μ (4 θ)	81.62	73.02	84.21	93.20	90.22	65.51	58.77	69.37	84.49	93.01	92.51
74 μ	84.88	77.56	87.57	95.07	92.36	67.99	62.97	70.98	86.75	94.36	93.26
88 μ	87.79	81.65	90.53	96.55	94.15	70.66	67.57	72.90	88.81	95.40	93.94
105 μ	90.27	85.19	92.98	97.63	95.53	73.52	72.49	75.29	90.70	96.18	94.55
125 μ (3 θ)	92.22	88.05	94.80	98.33	96.50	76.48	77.40	78.21	92.36	96.72	95.06
149 μ	93.72	90.35	96.09	98.74	97.16	79.59	82.20	81.74	93.86	97.07	95.46
177 μ	94.81	92.15	96.90	98.98	97.58	82.80	86.56	85.66	95.19	97.29	95.76
210 μ	95.66	93.64	97.42	99.13	97.88	86.09	90.38	89.73	96.40	97.47	95.98
250 μ (2 θ)	96.39	94.96	97.80	99.26	98.17	89.48	93.66	93.62	97.54	97.67	96.21
300 μ	97.13	96.23	98.19	99.42	98.50	92.87	96.36	96.89	98.57	97.96	96.50
350 μ	97.77	97.22	98.56	99.59	98.85	95.40	98.06	98.72	99.25	98.31	96.86
420 μ	98.55	98.28	99.06	99.78	99.30	97.77	99.39	99.75	99.79	98.81	97.43
500 μ (1 θ)	99.23	99.11	99.54	99.94	99.71	99.23	99.98	99.98	99.99	99.33	98.11
590 μ	99.74	99.65	99.89	100.0	99.96	99.89	100.0	100.0	100.0	99.75	98.80
710 μ	100.0	99.94	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.48
840 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.87
1000 μ (0 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1190 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1410 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1680 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2000 μ (-1 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% grainsize											
clay (<4μ)	17.63	10.43	18.31	27.16	28.00	22.90	14.95	32.14	20.60	20.42	24.63
silt (4μ - 63μ)	63.99	62.59	65.90	66.04	62.22	42.62	43.82	37.22	63.89	72.59	67.87
sand (63μ - 2 mm)	18.38	26.98	15.79	6.80	9.78	34.49	41.23	30.63	15.51	6.99	7.49

Drill hole and depth	AB09 5m	AB09 6m	AB09 7m	AB09 8m	AB09 9m	AB09 10m	AB09 11m	AB09 12m	AB09 13m	AB09 14m	AB09 15m
10 percentile (µ)	1.98	1.97	2.58	5.12	4.34	5.58	1.71	2.58	1.48	1.26	1.34
50 percentile (µ)	51.69	29.64	21.55	38.69	38.91	46.45	27.39	15.68	12.35	10.23	11.07
90 percentile (µ)	244.82	221.17	95.80	112.50	144.11	192.13	177.38	61.02	155.04	71.78	57.99
Mode (µ)	151.69	107.55	24.03	58.00	71.59	76.39	22.86	17.46	13.49	13.41	13.70
Secondary modes (µ)	13.49	14.57	433.06	438.81	0.83	0.78	125.90	0.82	323.80		
		0.75					0.73				
Cumulative Volume											
0.12 µ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 µ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 µ (11 θ)	1.41	1.64	0.82	0.47	0.69	0.58	1.94	0.75	1.39	1.69	1.66
0.98 µ (10 θ)	5.12	5.60	3.95	2.43	2.90	2.51	6.39	3.97	6.31	7.47	7.20
2 µ (9 θ)	10.09	10.14	7.99	4.87	5.56	4.72	11.12	7.94	13.46	15.80	14.23
3.9 µ (8 θ)	16.81	16.49	14.09	8.22	9.28	7.77	16.96	14.43	23.96	27.55	24.17
7.8 µ (7 θ)	25.19	25.80	24.42	13.71	15.09	12.87	25.16	27.07	38.19	42.88	39.52
15.6 µ (6 θ)	35.49	38.49	40.96	24.30	26.18	23.03	37.72	49.81	56.39	61.89	61.30
31 µ (5 θ)	44.57	50.72	60.29	42.27	43.39	38.87	52.70	74.78	72.35	78.53	80.35
37 µ	46.41	53.52	65.29	48.36	48.51	43.60	56.52	79.83	75.35	81.67	83.74
44 µ	48.20	56.27	70.18	54.90	53.72	48.44	60.22	84.01	77.89	84.30	86.50
53 µ	50.31	59.42	75.38	62.41	59.54	53.87	64.17	87.70	80.26	86.73	88.96
62.5 µ (4 θ)	52.57	62.49	79.87	69.23	64.85	58.85	67.66	90.35	82.11	88.60	90.80
74 µ	55.48	65.98	84.21	76.06	70.38	64.07	71.25	92.56	83.84	90.29	92.41
88 µ	59.22	69.89	88.24	82.52	76.02	69.44	74.95	94.38	85.46	91.83	93.82
105 µ	63.87	74.11	91.72	88.14	81.51	74.79	78.74	95.84	86.99	93.22	95.05
125 µ (3 θ)	69.14	78.30	94.39	92.45	86.46	79.78	82.51	96.97	88.39	94.43	96.06
149 µ	74.87	82.34	96.31	95.49	90.76	84.36	86.30	97.84	89.71	95.51	96.93
177 µ	80.53	85.96	97.50	97.33	94.19	88.32	89.96	98.50	90.97	96.47	97.68
210 µ	85.81	89.13	98.20	98.33	96.82	91.67	93.37	99.05	92.22	97.35	98.37
250 µ (2 θ)	90.52	91.92	98.61	98.83	98.69	94.50	96.40	99.50	93.56	98.19	99.01
300 µ	94.49	94.41	98.92	99.13	99.82	96.81	98.72	99.86	95.02	98.95	99.56
350 µ	97.01	96.22	99.19	99.35	100.00	98.27	99.82	99.98	96.28	99.45	99.88
420 µ	99.00	98.00	99.54	99.65	100.00	99.41	100.00	100.00	97.71	99.85	99.99
500 µ (1 θ)	99.94	99.25	99.85	99.91	100.00	99.95	100.00	100.00	98.88	99.97	100.00
590 µ	100.00	99.94	100.00	100.00	100.00	100.00	100.00	100.00	99.65	100.00	100.00
710 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
840 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1000 µ (0 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1190 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1410 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 µ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 µ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4µ)	16.81	16.49	14.09	8.22	9.28	7.77	16.96	14.43	23.96	27.55	24.17
silt (4µ - 63µ)	35.76	46.00	65.78	61.01	55.58	51.09	50.69	75.92	58.15	61.04	66.62
sand (63µ - 2 mm)	47.43	37.51	20.13	30.77	35.15	41.15	32.34	9.65	17.89	11.40	9.20

Drill hole and depth	AB09 16m	AB09 17m	AB09 18m	AB09 19m	AB10 1m	AB10 2m	AB10 3m	AB10 4m	AB10 5m	AB10 6m	AB10 7m
10 percentile (µ)	1.10	0.96	1.81	1.72	1.41	1.95	2.45	1.39	1.25	3.91	4.94
50 percentile (µ)	8.49	6.74	108.0	73.75	31.00	43.55	33.23	20.54	27.88	26.32	29.05
90 percentile (µ)	59.19	181.7	274.9	205.9	282.1	245.4	210.3	251.9	247.9	124.9	122.6
Mode (µ)	12.98	2.76	143.0	127.5	123.0	109.0	95.99	11.90	124.7	27.16	30.17
Secondary modes (µ)	335.5	11.58	2.83	3.28	2.22	2.75	24.33	150.9	13.90	0.72	0.76
		214.7	14.42		19.48	15.09	0.72	0.72	0.68		
Cumulative Volume											
0.12 µ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 µ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 µ (11 θ)	1.94	2.33	1.38	1.02	0.96	0.43	1.26	2.15	2.81	0.83	0.45
0.98 µ (10 θ)	8.67	10.24	5.22	4.81	5.84	3.43	4.69	7.43	8.25	3.26	2.33
2 µ (9 θ)	18.83	23.12	10.97	11.96	14.87	10.29	8.50	13.11	13.73	5.86	4.52
3.9 µ (8 θ)	32.26	38.81	18.15	22.82	24.27	18.96	14.23	20.92	20.65	9.98	8.12
7.8 µ (7 θ)	47.90	52.71	23.97	32.58	32.27	27.24	22.39	31.82	29.72	17.81	15.22
15.6 µ (6 θ)	66.18	65.46	28.44	39.13	40.80	36.05	34.20	45.12	40.89	33.29	29.94
31 µ (5 θ)	81.70	75.64	31.89	42.88	50.00	45.02	48.55	56.05	51.54	55.51	52.25
37 µ	84.52	77.42	32.25	43.23	52.36	47.49	52.25	58.31	54.07	61.34	58.34
44 µ	86.84	78.88	32.56	43.66	54.74	50.17	55.88	60.46	56.58	66.76	64.13
53 µ	88.92	80.21	33.27	44.71	57.46	53.46	59.83	62.83	59.43	72.17	70.02
62.5 µ (4 θ)	90.49	81.29	34.74	46.66	60.10	56.81	63.43	65.07	62.17	76.52	74.87
74 µ	91.89	82.38	37.55	50.08	63.09	60.70	67.27	67.58	65.22	80.52	79.41
88 µ	93.15	83.57	42.19	55.28	66.48	65.10	71.33	70.40	68.64	84.15	83.58
105 µ	94.26	84.93	48.77	62.15	70.21	69.87	75.53	73.52	72.35	87.34	87.26
125 µ (3 θ)	95.19	86.41	56.72	69.90	74.05	74.62	79.59	76.79	76.14	90.01	90.30
149 µ	95.97	88.04	65.42	77.81	77.90	79.23	83.47	80.18	79.96	92.24	92.75
177 µ	96.60	89.73	73.77	84.85	81.52	83.40	86.93	83.51	83.58	94.04	94.63
210 µ	97.14	91.46	81.13	90.57	84.86	87.08	89.98	86.74	86.97	95.51	96.06
250 µ (2 θ)	97.64	93.23	87.28	94.91	87.99	90.32	92.66	89.87	90.14	96.75	97.19
300 µ	98.16	95.03	92.14	97.95	90.97	93.18	95.01	92.85	93.09	97.81	98.09
350 µ	98.59	96.46	95.15	99.42	93.26	95.21	96.66	95.05	95.23	98.55	98.69
420 µ	99.10	97.96	97.66	99.98	95.66	97.17	98.22	97.18	97.32	99.25	99.25
500 µ (1 θ)	99.53	99.08	99.08	100.0	97.56	98.59	99.27	98.67	98.78	99.71	99.64
590 µ	99.84	99.76	99.71	100.0	98.91	99.51	99.86	99.55	99.65	99.97	99.89
710 µ	100.0	100.0	99.95	100.0	99.80	99.98	100.0	99.97	100.0	100.0	100.0
840 µ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1000 µ (0 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1190 µ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1410 µ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1680 µ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2000 µ (-1 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% grainsize											
clay (<4µ)	32.26	38.81	18.15	22.82	24.27	18.96	14.23	20.92	20.65	9.98	8.12
silt (4µ - 63µ)	58.23	42.47	16.59	23.84	35.82	37.85	49.20	44.15	41.51	66.54	66.74
sand (63µ - 2 mm)	9.51	18.71	65.26	53.34	39.90	43.19	36.57	34.93	37.83	23.48	25.13

Drill hole and depth	AB10 8m	AB10 9m	AB10 10m	AB10 11m	AB10 12m	AB11 1m	AB11 2m	AB11 3m	AB11 4m	AB11 5m	AB11 6m
10 percentile (μ)	3.84	2.01	2.00	2.14	16.35	5.93	2.18	4.69	2.47	2.93	3.59
50 percentile (μ)	22.42	142.1	133.2	185.5	216.2	140.4	62.94	91.90	49.78	46.79	24.39
90 percentile (μ)	245.4	432.8	388.5	451.7	454.3	319.4	282.6	312.6	305.0	257.9	98.78
Mode (μ)	21.05	266.7	142.6	286.9	266.0	180.5	178.8	186.3	192.0	124.4	28.17
Secondary modes (μ)	385.0	21.92	2.27	2.60	2.19	16.03	16.21		16.42		
	0.86	0.65	0.69	0.65	18.91						
		2.60	15.75	19.96							
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.04	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	0.48	2.45	2.28	2.38	0.81	0.23	1.02	0.40	0.99	0.99	0.49
0.98 μ (10 θ)	2.63	6.31	6.14	5.93	2.65	1.56	4.43	2.19	4.11	3.77	2.77
2 μ (9 θ)	5.43	9.96	9.99	9.59	4.76	3.93	9.24	4.81	8.30	7.31	5.83
3.9 μ (8 θ)	10.13	13.61	13.64	13.51	6.76	7.50	15.78	8.70	14.32	12.36	10.75
7.8 μ (7 θ)	19.34	17.15	16.35	16.72	8.37	11.68	23.53	14.16	22.42	19.20	19.40
15.6 μ (6 θ)	37.56	21.56	19.20	19.70	9.89	16.35	32.19	21.84	32.60	29.16	35.52
31 μ (5 θ)	60.88	26.82	21.56	22.93	11.50	20.85	40.92	31.26	43.07	41.86	58.30
37 μ	66.21	28.16	21.72	23.75	11.88	21.76	43.08	33.79	45.65	45.31	64.34
44 μ	70.83	29.52	21.93	24.59	12.28	22.64	45.19	36.31	48.17	48.76	70.01
53 μ	75.07	31.16	22.69	25.64	12.87	23.83	47.57	39.17	50.95	52.57	75.68
62.5 μ (4 θ)	78.19	32.91	24.33	26.81	13.71	25.41	49.90	41.93	53.54	56.09	80.23
74 μ	80.79	35.15	27.40	28.38	15.10	27.91	52.65	45.12	56.40	59.89	84.35
88 μ	82.91	38.08	32.28	30.55	17.33	31.78	56.01	48.94	59.63	64.01	87.96
105 μ	84.57	41.81	39.00	33.51	20.73	37.35	60.11	53.52	63.30	68.42	90.96
125 μ (3 θ)	85.83	46.25	46.93	37.34	25.46	44.47	64.85	58.75	67.29	72.90	93.25
149 μ	86.86	51.45	55.50	42.25	31.74	53.00	70.19	64.64	71.65	77.40	94.95
177 μ	87.81	57.18	63.74	48.18	39.43	62.15	75.76	70.82	76.15	81.68	96.15
210 μ	88.85	63.36	71.22	55.16	48.37	71.32	81.31	77.06	80.70	85.68	97.03
250 μ (2 θ)	90.15	70.02	77.84	63.17	58.43	80.02	86.64	83.16	85.24	89.38	97.73
300 μ	91.81	77.09	83.62	72.05	69.23	87.75	91.49	88.85	89.62	92.75	98.36
350 μ	93.41	82.88	87.66	79.43	77.90	92.87	94.81	92.86	92.87	95.15	98.84
420 μ	95.40	89.08	91.55	87.29	86.79	97.13	97.69	96.48	96.00	97.38	99.35
500 μ (1 θ)	97.19	93.94	94.44	93.28	93.32	99.45	99.37	98.75	98.17	98.89	99.73
590 μ	98.59	97.30	96.50	97.25	97.49	100.0	99.99	99.90	99.45	99.73	99.96
710 μ	99.64	99.48	98.09	99.62	99.80	100.0	100.0	100.0	100.0	100.0	100.0
840 μ	99.99	100.0	98.95	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1000 μ (0 θ)	100.0	100.0	99.44	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1190 μ	100.0	100.0	99.78	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1410 μ	100.0	100.0	99.97	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1680 μ	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2000 μ (-1 θ)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% grainsize											
clay (<4μ)	10.13	13.61	13.64	13.51	6.76	7.50	15.78	8.70	14.32	12.36	10.75
silt (4μ - 63μ)	68.05	19.30	10.69	13.30	6.95	17.91	34.12	33.23	39.22	43.73	69.48
sand (63μ - 2 mm)	21.81	67.09	75.67	73.19	86.29	74.59	50.10	58.07	46.46	43.91	19.77

Drill hole and depth	AB11 7m	AB11 8m	AB11 9m	AB11 10m	AB11 11m	AB11 12m	AB11 13m	AB11 14m	AB11 15m	AB11 16m	AB11 17m
10 percentile (μ)	2.37	3.99	5.38	3.94	7.96	8.01	9.06	10.17	9.15	7.66	6.46
50 percentile (μ)	17.41	24.94	32.35	25.36	74.73	89.15	182.17	150.14	124.04	121.31	76.78
90 percentile (μ)	79.24	87.04	92.72	102.44	222.53	276.93	404.72	327.45	303.65	367.06	536.37
Mode (μ)	20.26	30.46	46.71	29.89	111.88	155.74	240.76	209.31	184.11	228.89	418.28
Secondary modes (μ)		391.69					25.42	28.79			52.52
Cumulative Volume											
0.12 μ (13 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.24 μ (12 θ)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.49 μ (11 θ)	0.66	0.43	0.30	0.41	0.14	0.22	0.12	0.11	0.23	0.26	0.33
0.98 μ (10 θ)	3.78	2.49	1.90	2.44	1.27	1.37	1.10	1.02	1.34	1.52	1.90
2 μ (9 θ)	8.42	5.26	4.04	5.23	2.96	3.08	2.83	2.41	2.97	3.39	4.06
3.9 μ (8 θ)	15.78	9.80	7.52	9.91	5.62	5.73	5.52	4.62	5.38	6.12	6.96
7.8 μ (7 θ)	27.50	18.12	13.97	18.51	9.84	9.80	9.12	8.16	8.94	10.13	11.50
15.6 μ (6 θ)	46.42	34.22	26.80	34.54	17.13	16.81	13.60	13.73	14.54	16.52	19.77
31 μ (5 θ)	68.83	57.99	48.38	56.82	27.73	27.21	18.84	21.65	22.31	25.03	31.89
37 μ	73.99	64.48	55.30	62.80	31.06	30.25	20.16	23.78	24.45	27.41	35.37
44 μ	78.56	70.63	62.42	68.50	34.74	33.37	21.37	25.72	26.58	29.84	38.83
53 μ	82.86	76.84	70.16	74.31	39.32	37.00	22.61	27.61	29.03	32.59	42.57
62.5 μ (4 θ)	86.14	81.83	76.79	79.04	44.07	40.57	23.74	29.20	31.49	35.25	45.89
74 μ	88.99	86.34	83.04	83.39	49.65	44.71	25.17	31.00	34.56	38.28	49.27
88 μ	91.40	90.22	88.56	87.22	56.07	49.61	27.22	33.46	38.58	41.83	52.69
105 μ	93.35	93.34	92.98	90.40	63.11	55.30	30.34	37.16	43.85	46.04	56.10
125 μ (3 θ)	94.83	95.57	96.06	92.82	70.21	61.54	34.82	42.45	50.31	50.88	59.37
149 μ	95.93	97.07	97.96	94.59	77.09	68.23	40.98	49.64	57.97	56.49	62.57
177 μ	96.72	97.96	98.91	95.82	83.23	74.87	48.59	58.29	66.23	62.66	65.69
210 μ	97.33	98.46	99.29	96.71	88.45	81.20	57.37	67.79	74.57	69.27	68.87
250 μ (2 θ)	97.83	98.78	99.41	97.43	92.74	87.01	66.95	77.45	82.53	76.22	72.30
300 μ	98.31	99.04	99.47	98.08	96.08	92.08	76.74	86.39	89.59	83.22	76.20
350 μ	98.70	99.27	99.57	98.59	98.06	95.40	84.16	92.39	94.21	88.53	79.75
420 μ	99.15	99.55	99.74	99.14	99.51	98.17	91.28	97.26	97.92	93.67	84.16
500 μ (1 θ)	99.53	99.81	99.90	99.58	99.99	99.66	96.13	99.78	99.85	97.19	88.37
590 μ	99.83	99.97	100.00	99.87	100.00	100.00	98.93	100.00	100.00	99.22	92.09
710 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.60
840 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.95
1000 μ (0 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.51
1190 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97
1410 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1680 μ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2000 μ (-1 θ)	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
% grainsize											
clay (<4μ)	15.78	9.80	7.52	9.91	5.62	5.73	5.52	4.62	5.38	6.12	6.96
silt (4μ - 63μ)	70.36	72.03	69.27	69.14	38.45	34.84	18.22	24.58	26.11	29.13	38.93
sand (63μ - 2 mm)	13.86	18.17	23.21	20.96	55.93	59.43	76.26	70.80	68.51	64.75	54.11